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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of:	Stuart S. Goldstein et al
U. S. Serial No.	10/690,801
Filed:	22 October 2003
For:	METHOD FOR REVAMPING FIXED-BED CATALYTIC REFORMERS
Confirmation No.	5620
Group Art Unit:	1764
Examiner:	Prem C. Singh

Commissioner for Patents
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APPEAL BRIEF FOR APPLICANT

1. Real Party in Interest

The real party in interest in this application and in this appeal is the assignee of the entire right, title and interest to the invention and the application, ExxonMobil Research and Engineering Company, a corporation of Delaware and a wholly owned subsidiary of Exxon Mobil Corporation.

2. Related Appeals and Interferences

There are no prior or pending appeals, interferences or judicial proceedings which are related to, directly affect or will be directly affected by any decision of the Board in this appeal.

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3. Status of Claims

The status of the claims in the application is as follows:

Claims 1 - 4, 6 - 8, 10 - 20 are pending.
Claims 5 and 9 are cancelled
Claims 1 – 4, 6 – 8, 10 – 20 are rejected

The rejection of claims 1 – 4, 6 – 8, 10 – 20 is appealed.

4. Status of Amendments

There are no amendments filed subsequently to the final rejection.

5. Summary of the Claimed Subject Matter[1]

5.1 The claimed invention is in a method or scheme for converting fixed bed catalytic reforming units to moving-bed reactor operation. Catalytic reformers are used in petroleum refineries for converting low quality naphthas to higher quality (octane rating) gasoline-boiling range products and aromatic petrochemical feedstocks. Reforming units typically comprises a sequence of serially connected reactors with furnaces for supplying additional heat to the reaction stream as it passes from one reactor to the next in order to compensate for the heat taken up in the overall endothermic character of the process. Conventionally, reforming processes have been operated as semiregenerative or cyclic processes using fixed bed reactors or continuous processes using moving bed reactors. In recent years, continuous reforming units have been constructed in which a number of sequential moving-bed reactors are used for carrying out the reforming reactions with the catalyst leaving the final reactor in the series and passing continuously to a continuous catalyst regenerator through which the catalyst passes in continuous fashion while undergoing the steps of the regeneration process. Proposals have also been made for combining fixed and moving bed reactors in a hybrid configuration with the regeneration mode being appropriate to the reactor types used in the hybrid

types used in the hybrid configuration, so that the fixed bed reactors have retained the fixed bed type regeneration, usually semiregenerative, and the moving bed reactors in the unit have retained the dedicated moving bed regenerator.

5.2 Because the continuous mode of operation with its frequent regeneration of the catalyst can tolerate a higher degree of coke lay-down on the catalyst, it is possible to operate continuous units at lower pressures than those normally used with semi-regenerative and cyclic units in which it is important or at least desirable to extend catalyst life between successive regenerations. Operation at lower system pressures is desirable since it increases yield and product quality. One problem with replacement of existing fixed bed units with continuous units, however, is cost, particularly the cost of the continuous regenerator. The cost of the regenerator can be as much as about 80 percent of the total cost required for the replacement [0007]. There has been a need for an improved, less costly method for revamping existing fixed-bed reformers to obtain the benefits of continuous reforming.

5.3 The present invention provides a method or technique for converting fixed-bed, catalytic reformer units to moving-bed catalytic reformer units. The costs of conversion associated with the present conversion technique will be significantly less than replacement of the entire unit because the present technique makes use of existing facilities and does not require the dedicated, expensive onsite continuous integrated regenerator.

5.4 The claimed method for converting a fixed-bed catalytic reformer unit to a unit with moving bed reactors replaces the fixed-bed reactors of the existing unit with moving bed reactors but omits the regenerator section of the moving bed unit. In this way, the advantages of moving bed reforming are largely (but not completely) achieved since lower pressure operation becomes possible with improved product yield and quality; at the same time, the major expense connected with the moving bed regenerator is avoided, an important consideration in current conditions with slim refining margins.

[1] In this section and the rest of the brief, reference is made to the Section numbers of the specification by the use of brackets [].

5.5 The converted unit is provided with catalyst feed facilities for continuously or intermittently charging fresh or regenerated catalyst to the moving-bed reactors and, in addition, spent catalyst recovery facilities are added for collecting the spent catalyst, storing it temporarily, and transferring it to a catalyst regeneration facility. The existing facilities (piping, ancillary equipment) of the fixed-bed unit are re-used so as not to require replacement. The spent catalyst removed from the reactor is regenerated in a non-integrated regenerator which may be an offsite regenerator, a centrally located on-site regenerator which serves several reforming units or a regenerator shared with a second moving bed unit.

5.6 The converted unit is operated at an effective reactor pressure to improve reformate quality and yield compared to the reformate product from the fixed-bed unit before the conversion. Typically, this reactor pressure will be lower than that of the fixed bed unit whose reactors have been replaced but higher than the pressure which would be used in a full conversion to a continuous catalytic regenerator reformer with its own dedicated reactor. The use of a higher pressure than typical for a fully integrated continuous reactor-regenerator is desirable in that it enables the rate of catalyst flow for regeneration to be reduced (relative to that of an integrated unit) and so relieves the burden of catalyst handling.

5.7 Claim 1, in summary, is directed to a conversion method of this type [0008; page 4, l. 6] allied to its post-conversion operation in the new mode [0009] with the express limitation that there is no dedicated, continuous regenerator integrated with the moving bed reactor train [0008; page 4, l. 2]. The defined method comprises, in summary form, the following steps:

> Converting each fixed bed reforming reactor of the fixed-bed catalytic reformer unit to make a moving-bed catalytic reformer unit [0030; p. 10, l. 14] with a series train of moving bed reactors [0029; p. 10, l. 6; Fig: 27, 57, 65] fitted with facilities for handling the catalyst movement [0030; p. 10, l. 15; Fig: 11, 18, 20].
> Catalyst feeding facilities are added at the catalyst inlet of the moving bed reactor train for charging fresh or regenerated catalyst to the first continuous moving-bed

reactor through the catalyst inlet of the first reactor [0030; p. 10, l. 15; Fig: 11, 18, 20].;

Spent catalyst recovery facilities for collecting the spent catalyst from the catalyst outlet of the last moving bed reactor of the series train are also added [0030; Fig: 24, 71, 73]; the spent catalyst is transferred to a reforming catalyst regeneration facility which is not integrated with the reactor train from which the catalyst is removed [0031, p. 11, l. 18][0034, 0035; p. 12]

The moving-bed reactors are then operated at a lower effective pressure (than the fixed bed reactor pressures) [0019, p. 6]; the spent catalyst is transferred from the last moving-bed reactor to the non-integrated regeneration facility for regeneration [0034, 0035; p. 12].

5.8 Claim 18 is directed to this same type of conversion and operational method (with the same express limitation) and, in this case, specifies the effective operating pressures after the conversion as in the range of 1035 to 3800 kPag [0017; p. 6] and from 20 to 50 percent lower than the operating pressure of the fixed bed unit before the conversion [0011; p. 5, l. 4]

5.9 Claim 20 is also directed to the same type of conversion (with the same express limitation) and specifies that the moving-bed reactor is operated post-conversion at an effective pressure of 345 to 2760 kPag [0019; p. 7, l. 1] and lower than the operating pressure of the fixed bed reactor before the conversion [0019; p. 6, l. 33]. The regeneration in this case, is provided in a regenerator which is integrated with another moving bed unit so that the regenerator is shared between the two units [0021, page 7, ll. 21-28].

6 The Rejection

6.1. The Examiner has finally rejected claims 1-4, 6-8, 10-20 (all current claims) as unpatentable under 35 USC 103(a) over Golem in view of Dufresne. These references are identified as:

Golem:	NPRA Paper AM-89-47 ("Conversion of Fixed Bed Reformers to UOP CCR Platforming Technology")
Dufresne	U.S. 5,854,162

6.2 The basis of the Examiner's rejection is that although Golem does not disclose a non-integrated catalyst regeneration facility for the revamped reformer unit disclosed in this reference, it would have been obvious to the skilled person to modify Golem's teachings by using an offsite regenerator as taught by Dufresne because this would "allow better control of the two principle regeneration steps" (Final Rejection, page 4). With respect to the pressure conditions, the Examiner notes that the revamps described by Golem result in lower pressures being used in the process, with the actual pressures adjusted, based on the desired product composition.

7. The References

7.1 Golem

7.1.1 The economic factors underlying the revamps of conventional fixed-bed reforming units to continuous operation are discussed in the Golem reference. Golem et al imply in several instances that the cost of replacement of a fixed bed unit by a full continuous reforming unit with its moving bed reactors and its own regenerator is significant and, for this reason, recommends a number of approaches in which some of the benefits of the fully continuous operation may be obtained without going to the higher cost of a complete unit replacement. Note, for example, on page 6:

> "There are three avenues to obtaining some or all of the benefits of CCR Platforming technology...Each of the above options improves reforming efficiency; however, the improvements come with associated capital and utility costs."

> "The conversion of an existing, fixed bed unit to CCR Platforming technology provides an *affordable* approach to gain many of the benefits of CCR Platforming without purchasing a new unit." [Emphasis added]

On page 8, reference is made to the fact that in spite of the clear-cut technical advantages of CCR Platforming, most refiners have opted for the partial conversions described in the article:

> "Most of UOP's projects have resulted in conversions which range in cost from 25% to 50% of a new unit EEC."

7.1.2 Thus, it is clear that although the fully continuous reforming process exemplified by UOP's CCR™ Platforming™ and Axens Octanizing™ process technologies is technically superior both from the viewpoint of product yield and quality and catalyst performance, the economic factors in its refinery implementation provide an incentive for alternative solutions which, while less attractive from the technical point of view, represent better refining investment. The economic factors have therefore created a technical problem.

7.2 Dufresne

7.2.1 Dufresne relates to a process for the regeneration of a used hydrocarbon treatment catalyst which may be a reforming catalyst (abstract, column 1, lines 15-17, column 3, lines 31-35). In discussing the regeneration of reforming catalysts, Dufresne, notes the following:

> "When the catalytic reforming process is a continuous catalytic reforming (CCR) process, the catalyst progressively flows (circulating bed) through a number of reaction zones in which the feed circulates and where the chemical reactions associated with catalytic reforming take place, following which it is extracted from the final reaction zone and directed towards a regeneration zone. The duration of a (reaction+regeneration) cycle for the catalyst is generally in the range 0.1 to 10 days. Finally in this case, the catalyst is regenerated in a zone which is distinct from the reaction zones but in direct contact therewith." (col. 1, l. 60 et seq)

> "When the reforming reaction is a semi-regenerative type process (also known as a fixed bed process), the catalyst is present in reaction zones through which the feed circulates, but the catalyst does not circulate from one reaction zone to another while the chemical reactions associated with catalytic reforming are taking place. In this case, regeneration is periodically carried out, generally for 7

> to 10 or 15 days every 3 months to 12 months of use depending on the severity of the operations. The catalyst remains in the reaction zone which becomes the regeneration zone. Thus in this case the catalyst is regenerated in a zone which is also the reaction zone." (col. 2, l. 16 et seq)
>
> "There are also cases where the catalytic reforming process is a mixed technology process, i.e., one process combines reaction zones with semi-regenerative technology with reaction zones with continuous technology. In this case, the two types of regeneration are thus used." (col. 2, l. 35 et seq)

7.2.2 The Dufresne regeneration process is stated to have, as its objective, the provision of

> "[O]ffsite regeneration methods for used catalytic reforming catalysts which produce technical results which are at least as good and normally better than conventional onsite regeneration processes for catalytic reforming catalysts which are currently in use."
>
> "A further aim of the invention is to provide offsite regeneration methods for any used catalyst for the treatment of hydrocarbons containing at least one precious metal, preferably platinum, and in which regeneration must comprise at least one coke combustion step and one oxyhalogenation step, preferably oxychlorination, to redisperse the precious metal. The regeneration treatment of the invention can eliminate the major portion of the coke deposited on the support and redisperse the metallic phase."

7.2.3 The Dufresne process is therefore regarded correctly as an offsite reforming catalyst regeneration process (col. 3, line 31; column 4, line 33) which is characterized by two offsite steps of combustion and oxychlorination carried out under specific conditions (col. 3, lines 57-67). The spent catalyst which may be regenerated by this process may be "from a continuous and/or semi-regenerative type reforming process, i.e., a continuous type, semi-regenerative type or mixed type process." (col. 4, lines 16-19). When dealing with the catalyst from a continuous reforming process, which is the type the to which the present process approximates after unit conversion, Dufresne makes it clear that the off-site regeneration is intended to deal with *upset* conditions (col. 2, lines 44-59):

7.2.4 As noted by Dufresne (col.2, ll. 44-59), the regeneration in a CCR type process is directly affected by events in the reaction zones, and any abnormal operation of these zones has a direct effect on the operation of the regeneration zone, since the regeneration zone is generally only programmed for operation using normal conditions.

Thus any dysfunction, which manifests itself in a rise in the coke content in the catalyst to be regenerated compared with the normal content, generally 4% to 5% by weight of coke, requires either the catalyst regeneration rate to be reduced to avoid considerable exothermicity problems in the regeneration zone, meaning in total a reduction in the feed flow rate and thus a reduction in the production of the unit, which is costly to the refiner; or the catalyst must be completely changed and the used catalyst (if it cannot be re-used) given to a platinum recovery company. Further, coke combustion may be incomplete.

8 Applicant's Argument

8.1 Golem does not describe or suggest a reformer revamp in which fixed bed reactors are replaced by moving bed reactors without an integrated regenerator.

8.1.1 Golem describes three alternatives in the conversions of a fixed bed reformer unit to the UOP CCR technology, two of which are the full conversions to CCR with moving bed reactors and moving bed regenerators (first and second generation CCR Platforming options, see page 6). The third proffered option, referred to as the Hybrid CCR Platforming process, is the only option described in this reference as a lower cost alternative to the conversion to a complete CCR (page 16, Estimated Capital Cost approximately 55% of the next alternative).

8.1.2 The three conversion options reviewed by Golem (page 6) are:

Hybrid CCR conversion
Full CCR conversion (i.e. to a moving bed reactor stack *and a moving bed regenerator* with its high associated regenerator costs), and
Full CCR conversion, as above but using the second generation CCR technology with its lower operating pressure and faster catalyst circulation rate (pages 3, 14).
Hybrid conversion usually involving *addition* of a small moving bed reactor/regenerator combination following the existing fixed bed reactors (with a possibility of installing a larger regenerator for future full CCR utilization at significantly higher cost), but possibly a replacement. In any event, fixed bed

reactors are retained in use *as fixed bed reactors* in this hybridized processing scheme.

The faster catalyst circulation rate associated with the second generation CCR unit full conversion implies, of course, a larger regenerator the cost of which may be unattractive and unjustified (page 13 and page 16, indicating a capital cost more than twice as high as that of a full CCR conversion using the first generation technology and almost four times that of the Hybrid conversion).

8.1.3 The Hybrid CCR Platforming conversion utilizes the existing fixed bed reactors and *adds* a final moving bed reactor with its own associated regenerator which is sized only for the new moving bed reactor (see page 6) although it appears that replacement of a fixed-bed reactor by the moving bed reactor may be contemplated (second paragraph, page 7). Note also the final paragraph on page 7 which states:

> "If the revamp is the first step in a phased approach toward full CCR Platforming operations, the CCR regenerator is sized for use with the last moving bed reactor and a future reactor stack, which replaces the side-by-side reactors, or with a future reactor stack that replaces the entire reactor train. *The cost of the larger regenerator is significant and the project cost approaches that of a full CCR Platforming conversion.*" [Emphasis added]

Golem's hybridizing option also fails to overcome the inherent problems of the fixed bed unit since it retains the fixed bed reactors *as fixed bed reactors*. No attempt is made to obtain to the extent feasible, the advantages of moving bed reactor operation: golem's hybridizing option keeps the fixed bed reactors with their attendant disadvantages as compared to the presently claimed revamp removes each fixed bed reactor and installs a moving bed reactor. Note the language in claims 1 and 18 specifically requiring each fixed bed reactor to be converted to moving bed operation:

Claim 1 : "converting *each* fixed bed reforming reactor of a fixed-bed catalytic reformer unit to a moving-bed catalytic reformer unit comprising a series train of moving bed reactors

Claim 18: "converting *each* fixed bed reforming reactor of a fixed-bed catalytic reformer unit to a moving-bed catalytic reformer unit with each

> moving bed reactor connected in the train for reformer charge flow and for reforming catalyst flow from one reactor to the next in the train

Claim 20 is similarly limited:

> "converting at least the reactors of a fixed-bed catalytic reformer unit..... to a moving-bed catalytic reformer unit with a plurality of sequential moving bed reforming reactors in which each moving bed reactor is connected in a series train of moving bed reactors for reformer charge flow and for reforming catalyst flow from one reactor to the next in the train;"

The present revamp solution is therefore structurally different from Golem's hybridizing option in that no fixed-bed reactors remain after the conversion and operationally in that the advantages of moving bed reactor operation become available without the attendant cost of a full regenerator sized for the capacity of the entire unit.

8.1.4 Golem's discussion of these options (referred to also in NPRA Paper AM-03-93 (NPRA 2003 Annual Meeting), of record) indicates that the problem of regenerator cost was still not resolved by the options described in the paper: at the least, it was considered by the highly skilled UOP engineers that a moving bed regenerator had to be provided for the additional, final moving bed reactor in the cheaper Hybrid conversion.

8.1.5 Given that Golem does not teach the basis revamp or conversion scheme claimed in Applicant's main claims, the rejection is unwarranted by the facts since no notional combination of Golem with Dufresne or any other reference can be adduced as disclosing or suggesting the presently claimed method, at least as claimed in claims 1, 18 and 20. Nothing in Golem suggest a conversion in which all the fixed bed reactors are removed and replaced by a moving bed reactor stack and given this, no combination of other teachings with Golem can be taken as disclosing or suggesting the presently claimed method in which reactors are replaced but no regenerator provided in the manner contemplated by Golem. What Golem teaches is that if moving bed reactors are provided, they are accompanied by regeneration facilities on a one-on-one basis with the moving bed reactor stack.

8.2 Dufresne does not suggest offsite regeneration of catalyst from continuous reforming units lacking a regenerator

8.2.1 The Examiner has taken the view that the cost of Golem's full conversion options would provide a motive for the skilled person to replace onsite regeneration with Dufresne's offsite regeneration (Final Rejection, pages 5-6). As nice a piece of hindsight reconstruction as may have been produced in a long time. There is nothing in Golem which indicates the possibility of constructing or operating a continuous reforming unit without *at least one fully integrated regenerator* (in the Hybrid option it is the regenerator associated with the moving bed reactor at the end of the reactor train). Conversely, there is nothing in Dufresne which indicates the possibility of operating a continuous reforming unit *without its own integrated regenerator*. Dufresne, in fact, specifically alludes to the fact that the regeneration is dependent in its operation on the operation of the integrated moving bed reactors (col. 2, ll. 44-48). What Dufresne teaches is that if there be a "dysfunction" in the reactor which, for example, increases the coke-on-catalyst, the catalyst regeneration rate must be reduced, resulting in a reduction in overall reduction in throughput (col. 2, ll. 49-55). The other alternative, of a complete catalyst change (col. 2, ll. 56-58) is not an alternative which applies in the context of an operating unit: the unit has to be emptied and the catalyst sent away: there is no teaching or suggestion in Dufresne, as required by present claims 1 and 18, that "continuous or intermittent catalyst feeding facilities" should be added at the catalyst inlet of the moving bed reactor train and "feeding regenerated catalyst to the catalyst inlet of the first reactor in the train", or for "adding spent catalyst recovery facilities for collecting the spent catalyst from the catalyst outlet of the last moving bed reactor of the series train" in the event that there is "no dedicated continuous regenerator integrated with the series moving bed reactor train". In other words, Dufresne's teaching is limited to the context and circumstances of fully-integrated continuous reactor-regenerator unit operation.

8.2.2 It may be that the high costs of the integrated regenerator taught by Golem provide an *economic* motivation for the skilled person to find an alternative, lower cost solution but the question then arises what the *technical* solution of this motivation would be. If, as taught by Dufresne, the catalyst is to be completely changed, the unit is left

empty and non-functional until the changeover is made; in other words, no solution to the problem of ensuring continued operation is disclosed or suggested by Dufresne. Dufresne does not lead the skilled person to dispense completely with the regenerator but merely to supplement it when necessary. Dufresne does not teach the addition of the catalyst handling facilities at the inlet and outlet of the moving bed reactor sequence so as to enable continuous reactor operation to be achieved. The very least that can be said is that the Examiner has not provided any substantial evidence of record that the skilled person would, even in the face of the economic motivation, consider the design and construction of a unit intended for continuous operation which completely lacked an integrated regenerator. The present invention provides a conceptually novel technical solution to the economic problem.

8.3 The level of skill in the reforming art was insufficiently high for a person of ordinary skill to perceive the invention as obvious

8.3.1 Under *Graham v. John Deere Co.* 383 U.S. 1, 148 USPQ 459 (1966), a relevant inquiry is the level of skill in the art. Leaving aside meanderings such as positing a chemical engineer with a this degree or that and so much experience in the field neither of which do anything to illuminate the level of skill which actually prevailed in this art, it is more relevant and helpful to look at what was done in the light of the level of skill actually possessed. This shows that the level of skill in the art did not regard the invention as obvious at all for if it were, it would have been made earlier in light of the perceived need for it, as discussed below (Section 8.4).

8.3.2 The hypothetical person of skill in the art is only of ordinary skill and is not a genius. *Custom Accessories Inc. v. Jeffrey-Allan Industries Inc.* 807 F.2d 955, 1 USPQ 2d 1196, (Fed. Cir. 1986). It must be presumed that the engineers at UOP who worked on their well-established CCR Platforming units were highly skilled in the art of continuous reforming, having participated in or benefited from access to information about the innovation of such units and their subsequent development and use by a substantial number of licensees (as is clear from Golem's discussion) but they still did not have the extraordinary insight to make the conceptual leap to the present invention. This situation persisted, moreover, after Dufresne became available (1998): as late as

2003, the problem of regenerator cost was still implied by the NPRA paper from UOP (NPRA Paper AM-03-93 (NPRA 2003 Annual Meeting), of record): the CycleX ™ System offered as a lower cost option to "Full CCR Conversion" is clearly the hybrid option referred to by Golem (see slide "CycleX System Added to a Fixed-Bed Refomer"). The appearance of Dufresne did not, therefore, lead to any appreciation in the art that omission of a fully integrated regenerator was not only feasible but an attractive and desirable technical solution to this problem. The level of skill in the art permitted only the technical solution based on existing unit configurations, not those comparable to the present invention.

8.3.3 Since the invention was not obvious to persons who may be presumed to have possessed a high level of skill in the art, the hypothetical person with the lesser degree of ordinary skill must be taken to have an level of insight which also would have failed to perceive the invention as obvious. *Standard Oil Co. v. American Cyanamid Co.* 774 F.2d 448, 227 USPQ 293 (Fed. Cir. 1985) ("A person of ordinary skill in the art is also presumed to be one who thinks along the lines of conventional wisdom in the art and is not one who undertakes to innovate, whether by patient and often, expensive, systematic research or by extraordinary insights."). In accordance with the standards of *Graham*, the level of skill in the art was *not* sufficient to render the invention obvious because it certainly was not obvious to persons of great skill who were seeking a solution to the economic problem but lacked the technical appreciation and understanding to make the presently claimed invention. The person of ordinary skill must therefore be taken to lack the insight to make the invention.

8.4 The technical problem of a cheaper alternative to full continuous reforming was long standing and recognized in the art.

8.4.1 Under *Graham*, the so-called secondary considerations of obviousness may be probative of patentability under 35 USC 103 and, indeed, may be convincing since they are objective factors arising from the experience of the real world. Included among these secondary considerations are long-felt but unsolved needs and the failure of others. These factors are relevant to the present situation.

8.4.2 The Golem article which recognized the need for a low cost alternative to the full continuous reforming revamp. Page 6 of the paper refers to "an affordable approach to gain many of the benefits of CCR Platforming without purchasing a new unit"; page 8 (final paragraph) states that "The cost of the larger regenerator is significant and the project cost approaches that of a full CCR Platforming conversion"; page 10 refers in Case 1 to the Hybrid conversion resulting in the minimum cost which was achieved (page 11) by using a much smaller regenerator, sized only for the additional moving bed reactor, the cost of a full size CCR conversion is noted to be nearly $2mn more on a project costing $9.5mn (page 16). This concern over cost was with UOP, the designer of the CCR units and UOP obviously had little motive to sell cheaper units if the market would bear the cost of the full CCR conversions. The economic pressure for a low cost alternative to the full continuous unit was therefore recognized as early as 1989, the date of the Golem reference; this recognition, moreover, came from UOP itself which possessed probably unrivalled expertise in the technology and was a world leader in the engineering of continuous reforming units. The fact that UOP recognized the problem but was unable to come up with a solution that embodied the advantages of moving bed reactor operation without the huge cost of the moving bed regenerator, must surely be taken as evidence that the technical solution to the economic problem was not obvious to the highly skilled people in this art and that the problem persisted until the present invention was made[2].

8.4.3 The fact that Dufresne described offsite regeneration shortly before the present invention was made does not uniquely lead to the conclusion that Dufresne would have made the present invention obvious to the skilled person. As noted above (Section 8.3.2), the prevalent perception in the art at least as late as 2003 – several years after Dufresne - was that if a moving bed reactor stack were provided, it had to be accompanied by an integrated regenerator. Dufresne's disclosure was, in this sense, conceptually non-enabling. Dufresne does show that the *means* for achieving the advantages of moving bed reactor operation without the cost of the moving bed

[2] It is conceded that no evidence of commercial success is yet available. Given the major expenditures required for capital petroleum refinery installations (in the face of current thin refining margins), the length of time needed for technical and business evaluation and approval, the finding of a site for the initial commercial scale evaluation, the time taken in engineering design and construction of the plant, the need to align an offsite regeneration vendor and make

regenerator were available in the industry but technical availability does not equate with obviousness – were it to do so, virtually any invention might be shown to be obvious. The most that availability shows is that the invention might be possible but mere *possibility* does not imply obviousness: the prior art must in and of itself suggest the *desirability* of the claimed combination. *In re Nomiya* 509 F.2d 566, 184 USPQ 607, *In re Imperato* 486 F.2d 585, 179 USPQ 730 (CCPA 1973). *KSR International v. Teleflex Inc* 550 U.S. __ 2007, is not to the contrary. Indeed, *KSR* explicitly acknowledges that hindsight bias must be avoided, consistent with significant precedent:

> "A factfinder should be aware, of course, of the distortion caused by hindsight bias and must be cautious of arguments reliant upon *ex post* reasoning. See *Graham*, 383 U.S. at 36 (warning against a "temptation to read into the prior art the teachings of the invention in issue" and instructing courts to "guard against slipping into the use of hindsight" (quoting *Monroe Auto Equipment Co. v. Heckethorn Mfg. & Supply Co.*, 332 F.2d 406, 412 (CA6 1964)". Slip Op. p. 17
> "[T]o judge Asano against Engelgau would be to engage in the very hindsight bias Teleflex rightly urges must be avoided." Slip Op. p. 22.

The fact that Dufresne does not in any way imply or indicate the novel conceptual approach of modifying an otherwise conventional fixed bed reforming unit by replacing the fixed bed reactors in the unit by a moving bed reactor stack, omitting a regenerator and installing extra equipment at each end of the reactor stack for handling the catalyst to be sent for regeneration is indication in itself that the Examiner has pieced this invention together by forbidden hindsight bias. The jump from the actual practices of the prior art is certainly easy to conceive as based on the prior art when it is seen after the jump has been made but until that point is attained, the inventive solution remains remote and unforeseeable. The fact that, in this case, the problem had been obsessing the highly skilled workers at UOP at least for over a decade and continued to do so as late as 2003, shows that this conceptual leap was not apparent and not obvious to the skilled person even though once the leap had been made, the means to achieve it could be seen to be at hand.

technical and commercial arrangements for shipping of a costly catalyst containing significant amounts of noble metal, this is only to be expected at this early stage in the life of the invention.

8.5 The prior art fails to suggest the required step of operation at lower pressure without an integrated regenerator.

8.5.1 Claims 1, 18 and 20 all specify that the unit, after conversion, is to be operated at a pressure lower than that before the conversion is made. Claims 18 and 20 specify the relative extent of the pressure reduction. While lower pressure operation is characteristic of full continuous reformer operation (with fully integrated regeneration), there is nothing in the prior art which indicates that lower pressure operation might be utilized with a unit which lacked the fully integrated regenerator. As discussed in the record, the reforming catalyst becomes deactivated in use by the deposition of coke [0005] and this progressive deactivation is tolerable to a greater degree in the conventional continuous unit with its integrated regenerator because the coke is removed after a comparatively short time on line. With the removal of the integrated regenerator, however, the use of lower pressures becomes problematical because the faster accumulation of coke under lower pressure could rationally be expected to shorten the time during which the catalyst could be used, in which case, the operation would revert to a schedule even worse than that of the fixed bed units and this would be completely unacceptable. The prior art contains no suggestion or implication that if the integrated regenerator (characteristic of the continuous unit) is omitted, as required by claims 1, 18 and 20, that lower pressure operation could be tolerated. There is certainly no indication that operation within the pressure limits of claims 18 and 20 would be in any way acceptable with a unit lacking an integrated regenerator and for this reason, the record does not establish the obviousness of the invention set forth in these claims.

8.5.2 Claims 8, 11, 12 and 19 specify the relative pressures before and after the conversion. The prior art fails to suggest that operation of a converted unit with moving bed reactors would even be possible under such different pressure regimes without a fully integrated regenerator. Neither Golem nor Dufresne speak to this aspect of the invention: Golem does not teach replacement of all the fixed bed reactors without an integrated regenerator and Dufresne fails to explore the potential of operating a moving bed unit exclusively using offsite regeneration and therefore fails to suggest operation of the truncated unit under the lower pressure regime.

8.6 The prior art does not suggest the use of a shared regenerator

8.6.1 Claims 4 and 20 are directed to the arrangement in which a single continuous regenerator integrated with one moving bed reactor stack is used for regenerating the catalyst from the moving bed unit lacking the regenerator. It turns out that even though a continuous regenerator, conventional in type, is used in this arrangement, the economics are still favorable compared to those of two reformers each with its own integrated regenerator as the economies of scale work in its favor: a single moving bed regenerator for two reactor stacks costs less than two regenerators of the same total regeneration capacity. This concept is not recognized in either Golem or Dufresne and must therefore be considered as unobvious under 35 USC 103. Golem teaches only the conventional continuous full CCR units and the hybrid unit with each type having fully integrated regenerators. Dufresne teaches only fully integrated continuous reactor/regenerator units in the conventional one-on-one reactor stack/regenerator configuration. Again, the means to achieving such a conversion method were at hand in the conventional continuous reforming art but the insight provided by the present inventors, of economizing by sharing the regenerator between two or more units with regenerator services supplied by one of the units, was definitely not shown. The rejection of claims 4 and 20 is therefore not supported by substantial factual evidence.

8.6.2 The Examiner has argued on this point (rejection, page 7) that if Dufresne's offsite regenerator is processing catalysts from different processes, (Dufresne, col. 4, ll. 16-19), it is "definitely a shared-regenerator". A "shared regenerator", yes, but not shared by two units one of which lacks its own integrated regenerator. It takes a conceptual leap to go from Dufresne's regenerator being shared by "a continuous and/or semi-regenerative type reforming process, i.e. a continuous type, semi-regenerative type of mixed type process" with its connotation of the processes being conventional in type with – in the case of the continuous processes – fully integrated regenerators to a method in which the regenerator is totally eliminated for one of the units which are to be shared. Dufresne exists only in the context of the conventional type units.

8.7 The Examiner's arguments in favor of obviousness are based on the improper premise that the invention is obvious from the beginning.

In the response to Applicant's arguments (rejection, pages 6-7) the Examiner concludes as his initial premise that Dufresne and Golem together render the invention obvious and therefore that the distinctions adduced by Applicant in favor of unobviousness are not persuasive. This position begs the question in the classic manner and misstates the manner in which the case on obviousness *vel non* must be approached. The Examiner may not conclude obviousness as the premise for dismissing the differences presented in favor of unobviousness; the adduced differences must be considered before the conclusion is made. If this proper approach were taken, Applicant's point that none of the Golem options makes obvious a conversion method in which fixed bed reactors are replaced by moving bed reactors without the regenerator believed to be necessary up to that point is seen in a different light. The prior art does not in and of itself disclose or suggest that the claimed conversion in which a regenerator is omitted from a moving bed reactor stack could be made: all the schemes contemplated by Golem include a regenerator in a one-on-one relationship with the reactor stack and Dufresne operates also within this same realm. For this reason, it is improper to conclude that the claimed modification is obvious because it starts from an obvious combination of known teachings (in other words, that it is obvious because it is obvious).

9. Summary

The Examiner's rejection under 35 USC 103(a) is not warranted by the facts, is not supported by substantial evidence and is arbitrary, capricious and not in accordance with law. It should therefore be reversed.

For the Applicants,



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Claims Appendix

The claims on appeal, in their current form, are:

1. A method for the conversion of a fixed-bed catalytic reformer unit to moving bed reactor operation without a dedicated continuous catalyst regenerator, the method comprising:

converting each fixed bed reforming reactor of a fixed-bed catalytic reformer unit which includes a plurality of fixed bed reactors connected in a series train for reformer charge flow from one reactor to the next in the train to a moving-bed catalytic reformer unit comprising a series train of moving bed reactors that allows continuous or intermittent addition of freshly regenerated catalyst to a catalyst inlet of the first moving-bed reactor of the series train and continuous or intermittent removal of spent catalyst from a catalyst outlet of the last moving-bed reactor of the series train, with each moving bed reactor connected in the train for reformer charge flow and for reforming catalyst flow from one reactor to the next in the train;

adding continuous or intermittent catalyst feeding facilities at the catalyst inlet of the moving bed reactor train for charging fresh or regenerated catalyst continuously or intermittently to the first continuous moving-bed reactor through the catalyst inlet of the first reactor and feeding regenerated catalyst to the catalyst inlet of the first reactor in the train;

adding spent catalyst recovery facilities for collecting the spent catalyst from the catalyst outlet of the last moving bed reactor of the series train, there being no dedicated continuous regenerator integrated with the series moving bed reactor train, and transferring the spent catalyst to a reforming catalyst regeneration facility which is not integrated with the reactor train from which the catalyst is removed;

operating the moving-bed reactors at an effective pressure lower than the pressure at which the fixed bed reactor is operated before the conversion to improve reformate quality and yield relative to those of the reformate product from the fixed-bed unit before the conversion;

removing continuously or intermittently spent catalyst from the last moving-bed reactor of the series train; and transferring it to the non-integrated regeneration facility for regeneration.

2. The method of claim 1, in which the regeneration facility is a community onsite regeneration facility for a plurality of reforming units and in which the community onsite regeneration facility receives spent catalyst from the plurality of reforming units continuously or intermittently, regenerates the spent catalyst and supplies continuously or intermittently the plurality of reforming units with regenerated catalyst.

3. The method of claim 1, in which the regeneration facility is an off-site regeneration facility adapted to regenerate spent catalyst from a plurality of reforming units.

4. The method of claim 1, in which the regeneration facility is a moving bed regenerator integrated with a second moving bed reformer unit and of a capacity which enables it to accept the catalyst from the moving bed reactor of the converted unit after conversion.

6. The method of claim 1 in which the reformer charge flow in the reactor train is cocurrent with catalyst flow in the reactor train.

7. The method of claim 1 in which the moving bed reactors are operated after the conversion at a pressure lower than the pressure of the fixed bed reactor before conversion.

8. The method of claim 7 in which the fixed bed reactor is operated before the conversion at a pressure of 1035 to 3800 kPag and the moving bed reactor is operated after conversion at a pressure which is within the range of 1035 to 2620 kPag and at a value which is lower than that of the fixed bed reactor before conversion.

10. The method of claim 9 in which the moving bed reactor is operated at a pressure of 1035 to 2415 kPag after conversion.

11. The method of claim 7 in which the moving bed reactor is operated after the conversion at a pressure which is equal to 20 to 60 percent lower than the pressure within the range of 1035 to 3800 kPag at which the fixed bed reactor is operated before the conversion.

12. The method of claim 11 in which the moving bed reactor is operated after the conversion at a pressure which is equal to 25 to 50 percent lower than the pressure within the range of 1035 to 3800 kPag at which the fixed bed reactor is operated before the conversion.

13. The method of claim 1, in which the fresh or regenerated catalyst comprises one or more Group VIII noble metals on a refractory support.

14. The method of claim 1, in which the fresh or regenerated catalyst comprises a hydrogenation-dehydrogenation function and an acid function.

15. The method of claim 1, in which the fresh or regenerated catalyst comprises platinum, tin, rhenium or combinations thereof on a substantially spherical alumina support particle.

16. The method of claim 1, in which the fresh or regenerated catalyst comprises platinum, platinum and tin, or platinum and rhenium on substantially spherical alumina support particles.

17. The method of claim 1, in which the catalyst feeding facility is operatively connected with the moving-bed catalytic reformer reactor; the catalyst recovery facility is operatively connected with the moving-bed catalytic reformer reactor and the catalyst feeding facility, the catalyst recovery facility and the moving-bed catalytic reformer reactor are operatively connected with existing fixed-bed unit facilities including

reforming charge heaters and reformate product recovery facilities retained from the fixed bed unit.

18. A method for the conversion of a fixed-bed catalytic reformer unit to moving bed reactor operation without a dedicated continuous catalyst regenerator, the method comprising:

converting each fixed bed reforming reactor of a fixed-bed catalytic reformer unit which includes a plurality of fixed bed reactors connected in a series train for reformer charge flow from one reactor to the next in the train, the unit being operated at an operating pressure of from 1035 to 3800 kPag and at an effective pressure lower than the pressure at which the fixed bed reactor is operated before the conversion, to a moving-bed catalytic reformer unit having catalyst feeding facilities that allow continuous or intermittent addition of freshly regenerated catalyst to a catalyst inlet of the first moving-bed reactor of the series train and continuous or intermittent removal of spent catalyst from a catalyst outlet of the last moving-bed reactor of the series train, with each moving bed reactor connected in the train for reformer charge flow and for reforming catalyst flow from one reactor to the next in the train there being no dedicated continuous regenerator integrated with the series moving bed reactor train;

adding continuous or intermittent catalyst feeding facilities at the catalyst inlet of the first moving bed reactor for charging fresh or regenerated catalyst continuously or intermittently to the continuous moving-bed reactor through the catalyst inlet of the first reactor and feeding regenerated catalyst to the catalyst inlet of the first reactor in the train;

adding spent catalyst recovery facilities for collecting the spent catalyst from the catalyst outlet of the last moving bed reactor of the series train, and transferring the spent catalyst to a reforming catalyst regeneration facility which is not integrated with the reactor from which the catalyst is removed;

operating the moving-bed reactor at an effective pressure from 20 to 50 percent lower than the operating pressure of the fixed bed unit to improve

reformate quality and yield relative to those of the reformate product from the fixed-bed unit before the conversion;

removing continuously or intermittently spent catalyst from the moving-bed reactor; and transferring it to the non-integrated regeneration facility.

19. The method of claim 18 in which the fixed bed reforming unit includes a plurality of fixed bed reactors which are converted to a plurality of moving bed reactors operating at a pressure of 1035 to 2415 kPag and lower than the operating pressure of the fixed bed reactors.

20. A method for the conversion of a fixed-bed catalytic reformer unit to moving bed reactor operation, the method comprising:

converting at least the reactors of a fixed-bed catalytic reformer unit having a plurality of sequential fixed-bed catalytic reforming reactors to a moving-bed catalytic reformer unit with a plurality of sequential moving bed reforming reactors in which each moving bed reactor is connected in a series train of moving bed reactors for reformer charge flow and for reforming catalyst flow from one reactor to the next in the train;

adding continuous or intermittent catalyst feeding facilities at the catalyst inlet of the first moving bed reactor in the sequence of moving bed reactors in the train for charging fresh or regenerated catalyst continuously or intermittently to the continuous moving-bed reactor through the catalyst inlet of the first reactor and feeding regenerated catalyst to the catalyst inlet of the first reactor in the train, there being no dedicated continuous regenerator integrated with the series moving bed reactor train;

adding spent catalyst recovery facilities for collecting the spent catalyst from the catalyst outlet of the last moving bed reactor in the train of moving bed reactors, and transferring the spent catalyst to a reforming catalyst regeneration facility which comprises a reforming catalyst regenerator which is integrated with a second moving bed catalytic reforming unit but is not integrated with the moving bed reactor from which the catalyst is removed;

operating the moving-bed reactor at an effective pressure within the range of 345 to 2760 kPag and lower than the operating pressure of the fixed bed reactor unit before conversion to improve reformate quality and yield relative to those of the reformate product from the fixed-bed unit before the conversion;

removing continuously or intermittently spent catalyst from the last moving-bed reactor in the train; and transferring it to the regenerator, regenerating the catalyst in the regenerator and returning regenerated catalyst to the first moving bed reactor of the train of moving bed reactors in the converted unit.

Evidence Appendix

CycleX™ System for Increased Hydrogen from a Fixed-Bed Reformer

NPRA Paper AM-03-93 (NPRA 2003 Annual Meeting)

Submitted with Information Disclosure Statement of 2 August 2004, considered by Examiner 6 July 2006.

CycleX™ System for Increased Hydrogen from a Fixed-Bed Reformer



UOP Our Technology Touches the World

Clean Fuels and Hydrogen

Issues

- FCC Gasoline and Diesel Desulfurization

Needs

- Increased H_2 Quantity and Availability to Meet HDS Needs

Solutions

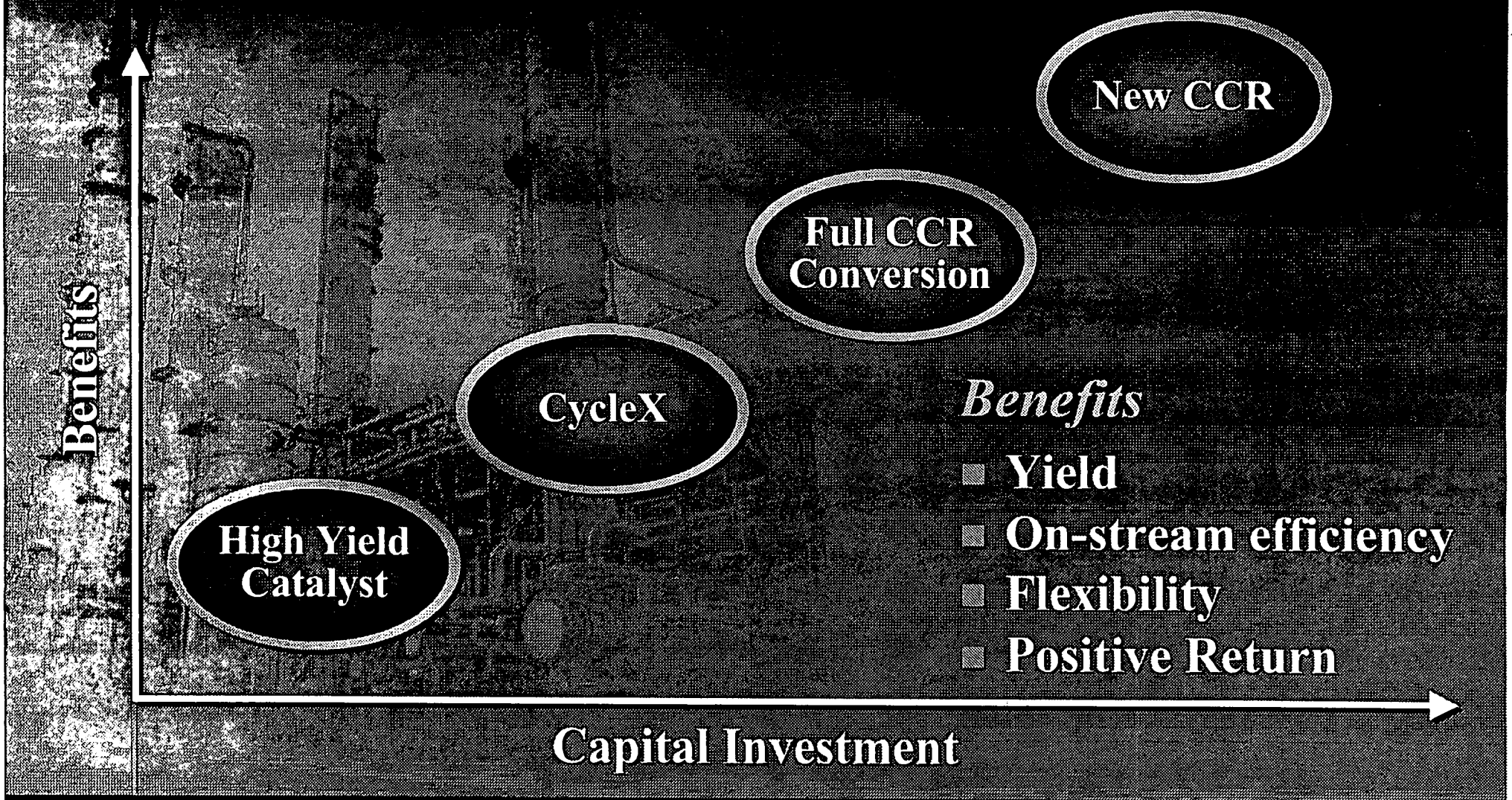
- Optimize network
 - PSA
 - Membrane
 - Hydrogen Plant
- Purchase if available
- Build H_2 Plant
- Upgrade Catalytic Reformer

Introducing a new reforming solution:

CycleX System

uop

Reforming Options to Increase H_2

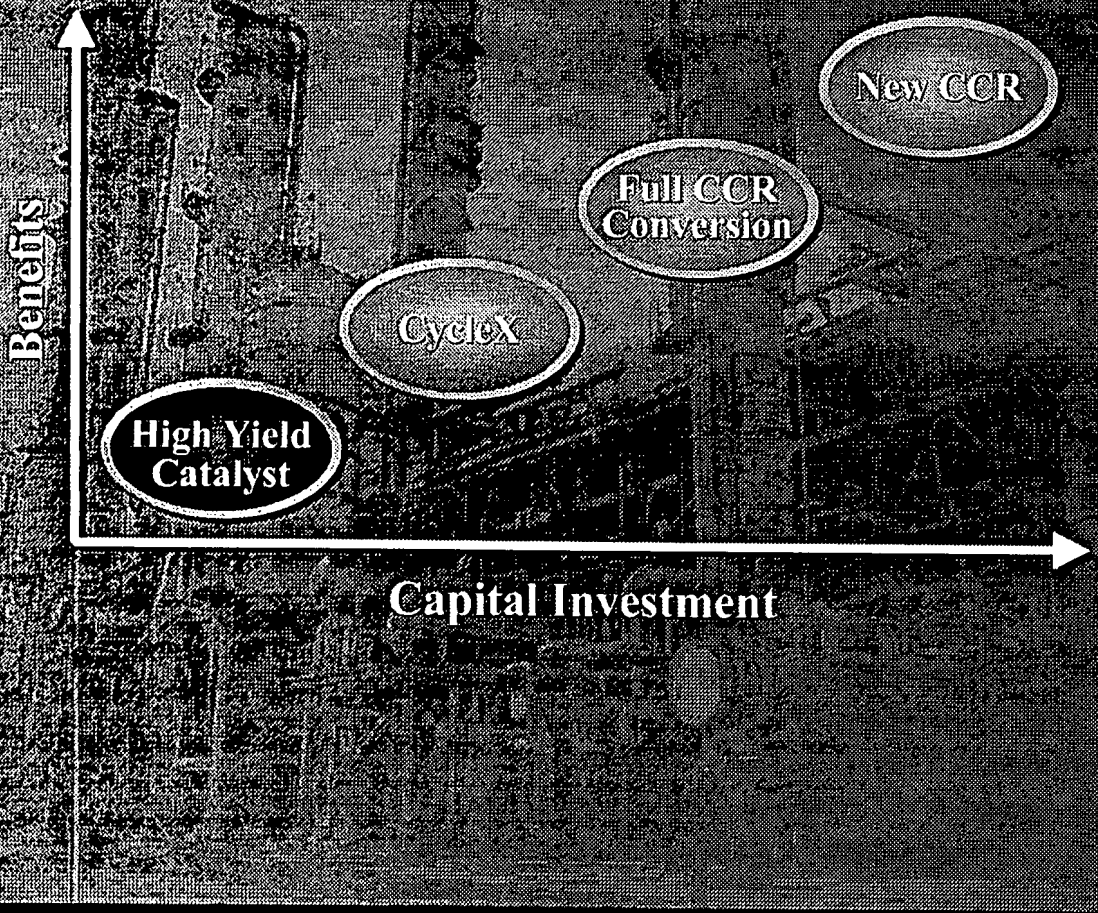


Benefits

- Yield
- On-stream efficiency
- Flexibility
- Positive Return

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High Yield Catalyst



Benefits

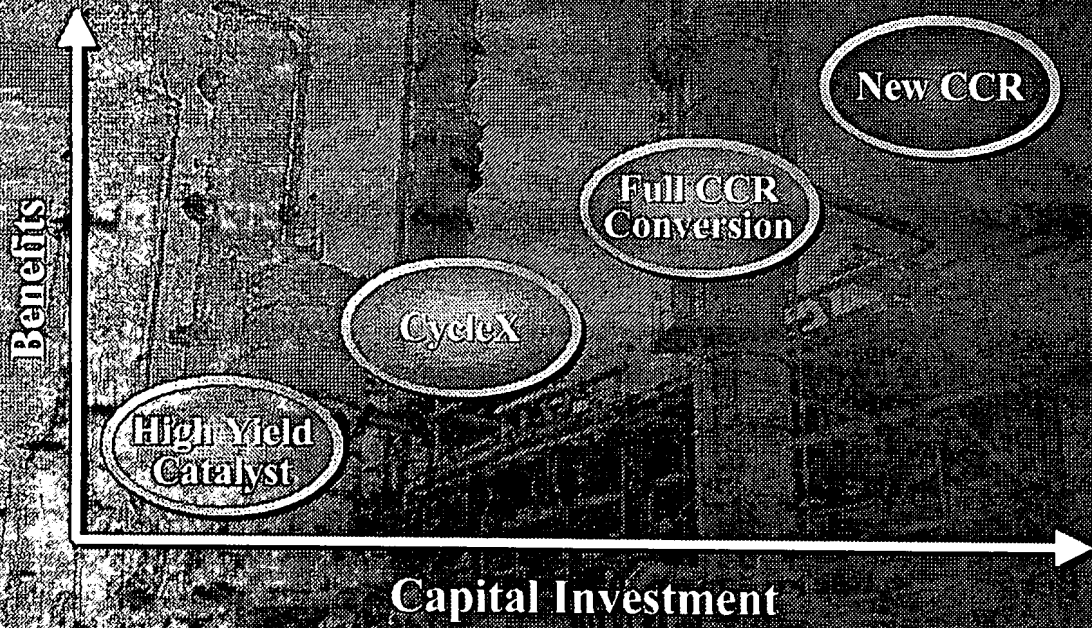
- Low investment
- Yield increase

Issues

- H_2 increase typically not sufficient
- Cycle length increase not significant for refiner's needs

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New CCR Platforming Unit



Benefits

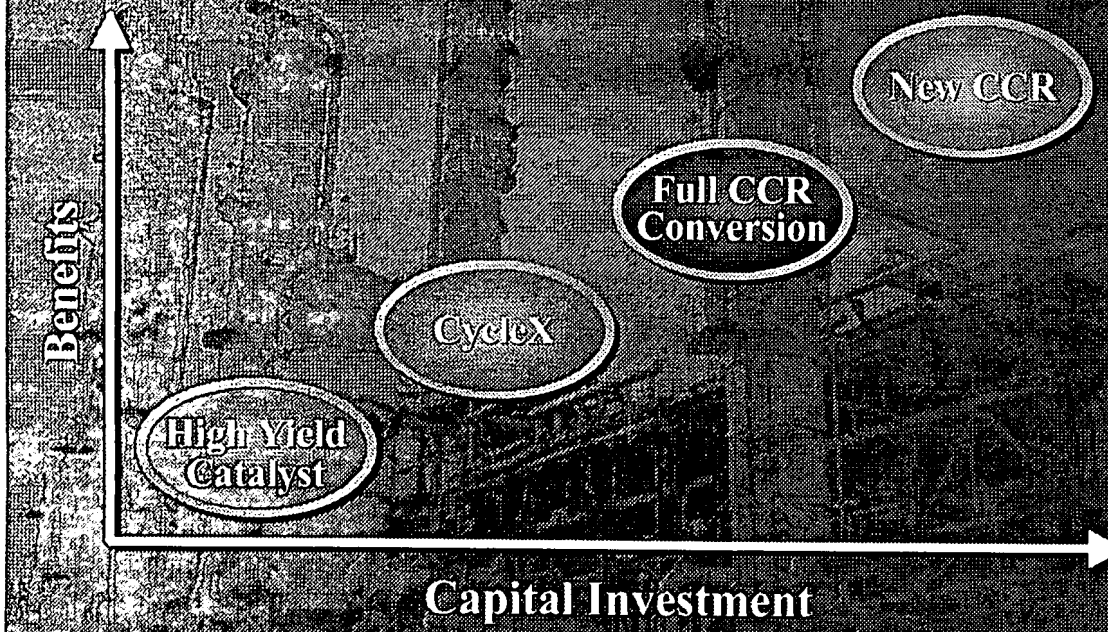
- Best utilization of feed
- Maximizes yields
- High on-stream efficiency
- Operating flexibility
- Reliable source of H_2

Issues

- Higher initial capital outlay
- Plot space

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Full CCR Conversion



Benefits

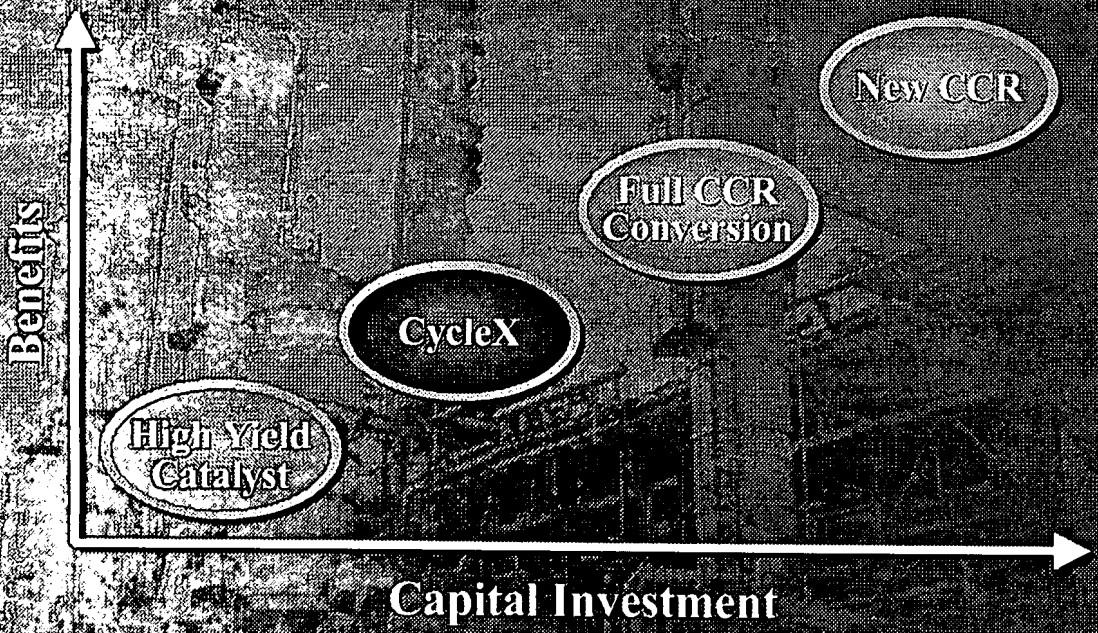
- Utilization of existing equipment
- Reduced capital cost

Issues

- Downtime for conversion
- Plot space

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CycleX System



Benefits

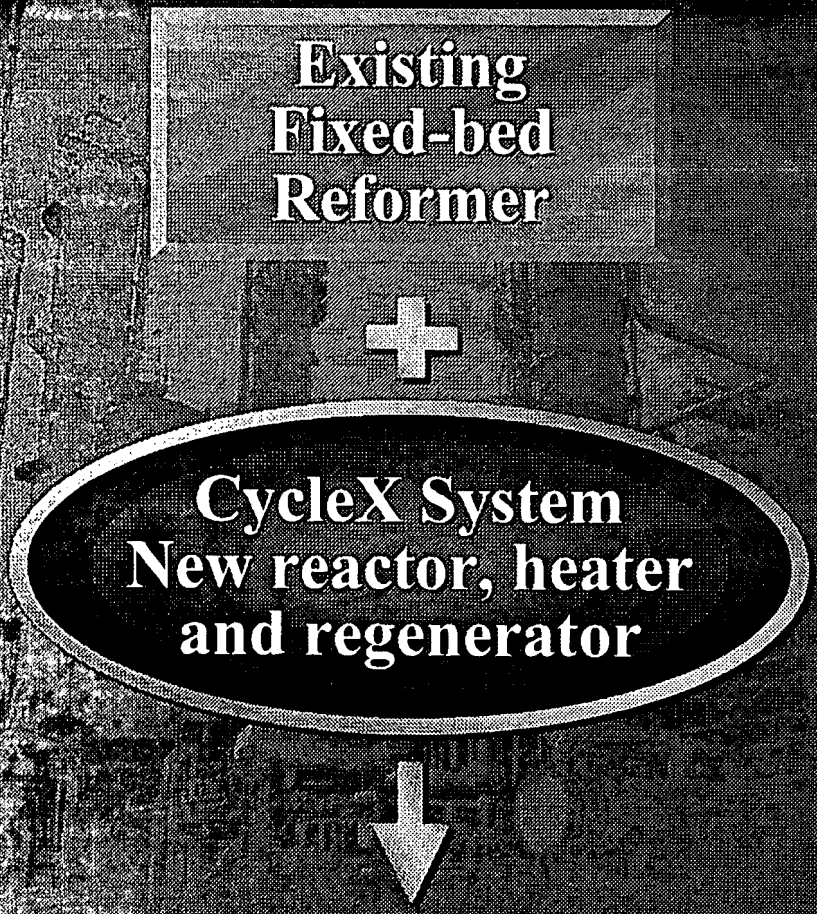
- Increased H_2 availability
- Increased H_2 and reformate yields
- Low capital cost
- Minimal downtime
- Small plot space

Issues

- Suitability of existing equipment

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CycleX System Overview



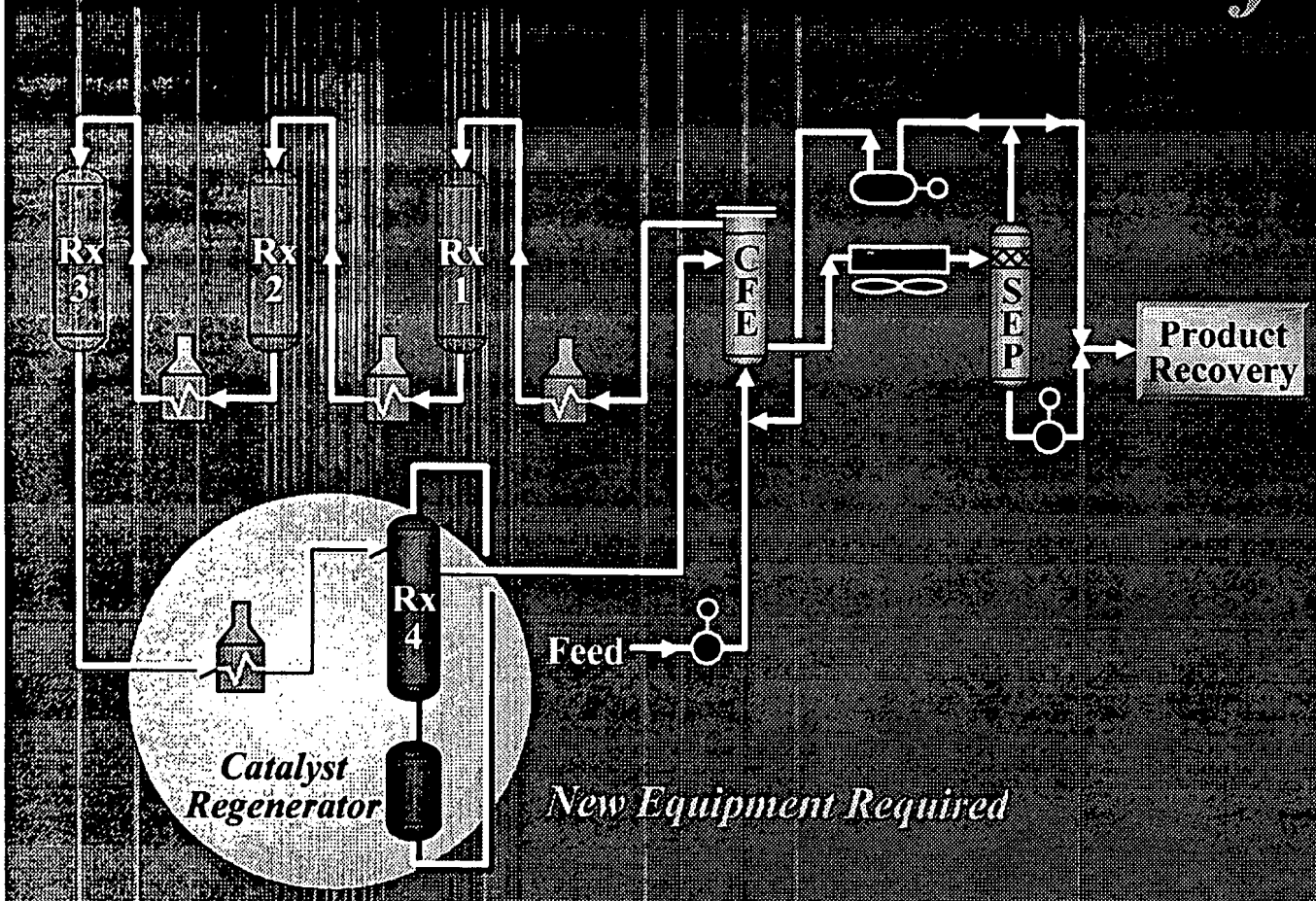
Operating Concept

- Reduce severity of fixed-bed reactors to extend cycle
- Lower operating pressure
- Addition of a circulating catalyst last reactor

Expanded capabilities of existing assets

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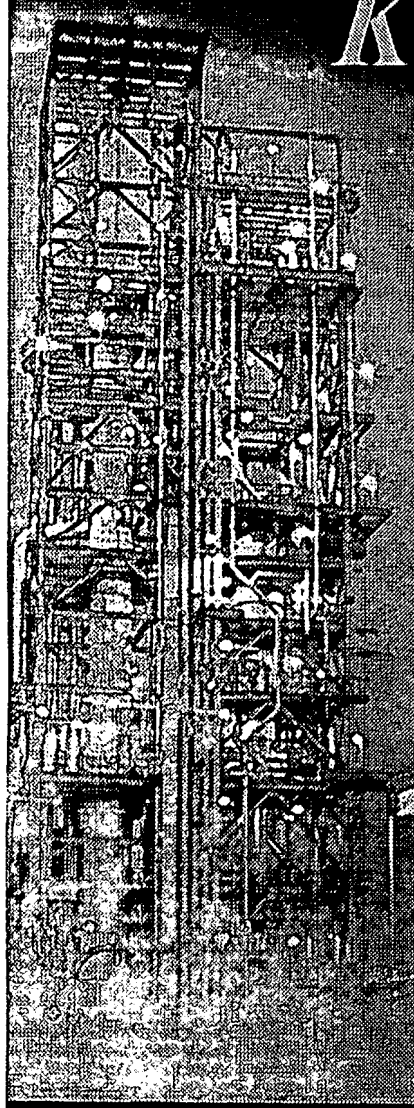
CycleX System Added to a Fixed-Bed Reformer



Key Features

- Minimizes changes to existing equipment
- Minimizes plot space
- Easily integrates into operating unit

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CycleX Addresses Key Revamp Considerations

- **Cost**
 - Maximize re-use of existing equipment
- **Downtime**
 - Shop-fabricated equipment
 - Minimal tie-ins
- **Plot space**
 - Catalyst regenerator below reactor
- **Operations**
 - Fixed-bed catalyst regeneration addressed

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CycleX System Implementation

UOP Scope of Supply

Basic Engineering	Detailed Engineering	Equipment – Procurement – Fabrication – Delivery to refinery	Site Installation

Advantages of UOP Supply

- Fixed-price cost
- Fast-track schedule (<12 months)
- Quality management system
- Experience
 - >15 years of Modular CCR equipment supply

uop

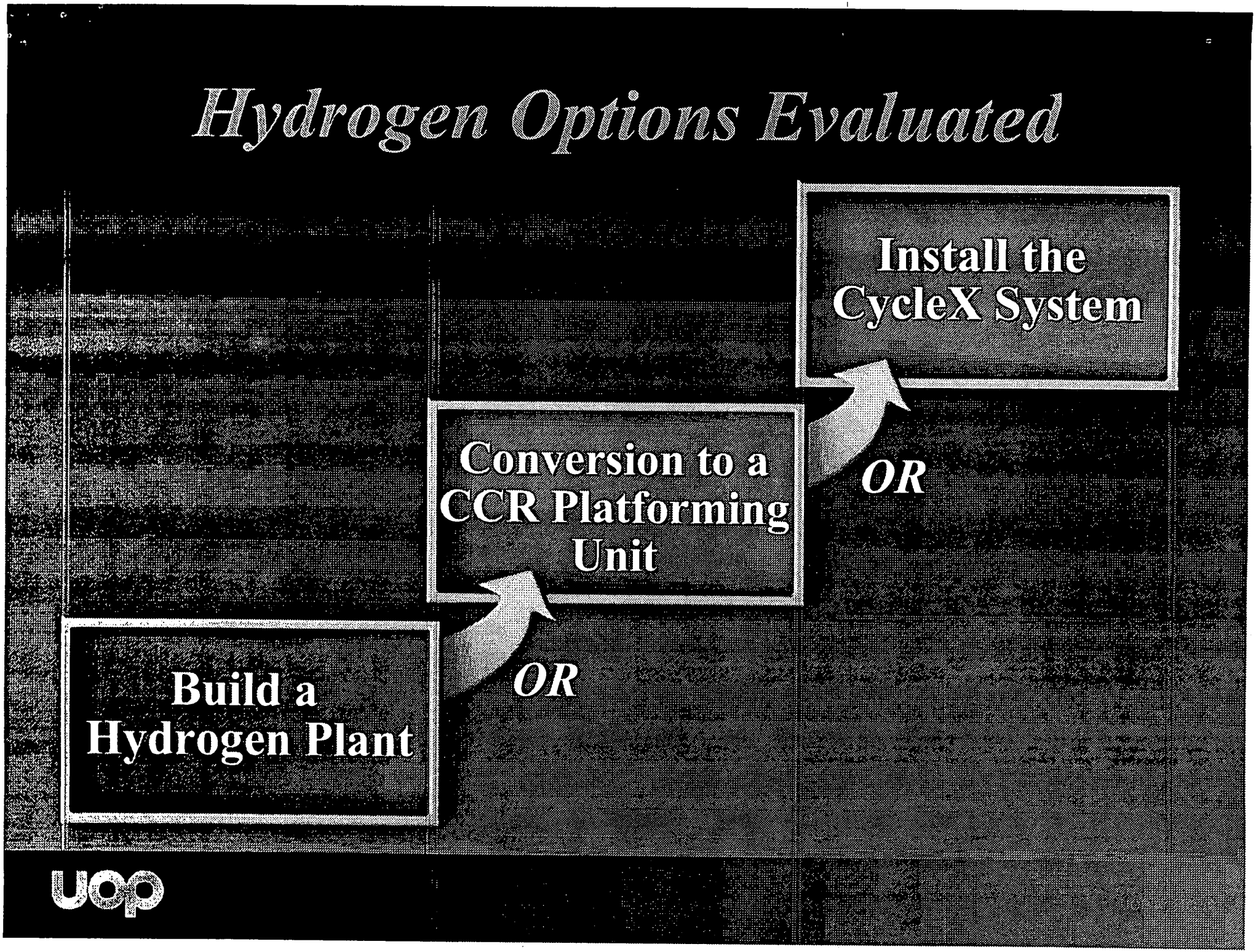
Case Study
2.4 MMSCFD H_2 Increase Needed

Basis

- Continuous source of hydrogen to match 2-year HDS unit cycle
- Increased hydrogen requirement
 - 2.4 MMSCFD (64.3 NM^3/day) or
 - 200 SCFB (34 NM^3/m^3) increase from a 12,000 BPSD reformer
- New CCR Platforming unit not an option
 - Capital and plot space constraints

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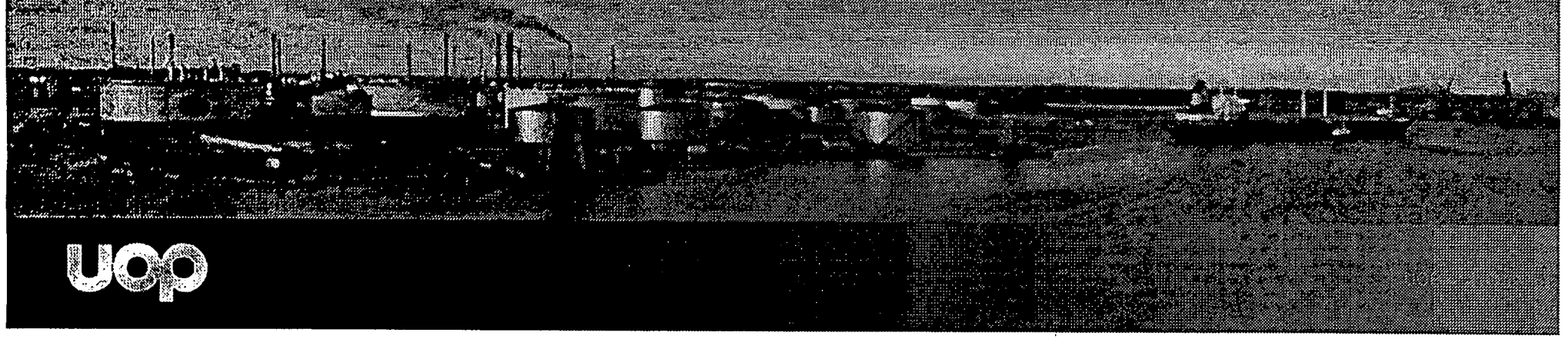
Hydrogen Options Evaluated



Hydrogen Options Evaluated

Build 2.4 MMSCFD Hydrogen Plant

- **US$ 5.0 MM ISBL installed cost**
 - **Feed compression *NOT* included**
 - **Natural gas feed**
 - **Modular design**
 - **Positive value for the HP steam generated**
- **Not enough hydrogen when fixed-bed reformer is down for regeneration**



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Case Study

	Current Fixed-Bed Operation	New Hydrogen Plant at 2.4 MMSCFD
Delta Yields		
H_2, SCFB (NM^3/M^3)	Base	—
C_5^+ octane-barrels per year, MM	Base	—
Delta Economic Analysis		
Pre-tax Gross Profit, $US MM/year	Base	1.3
Total Installed Cost, $US MM	Base	5.0
Pre-tax Simple Payback, years	Base	3.9
NPV over a 10-year period, $US MM	Base	1.5

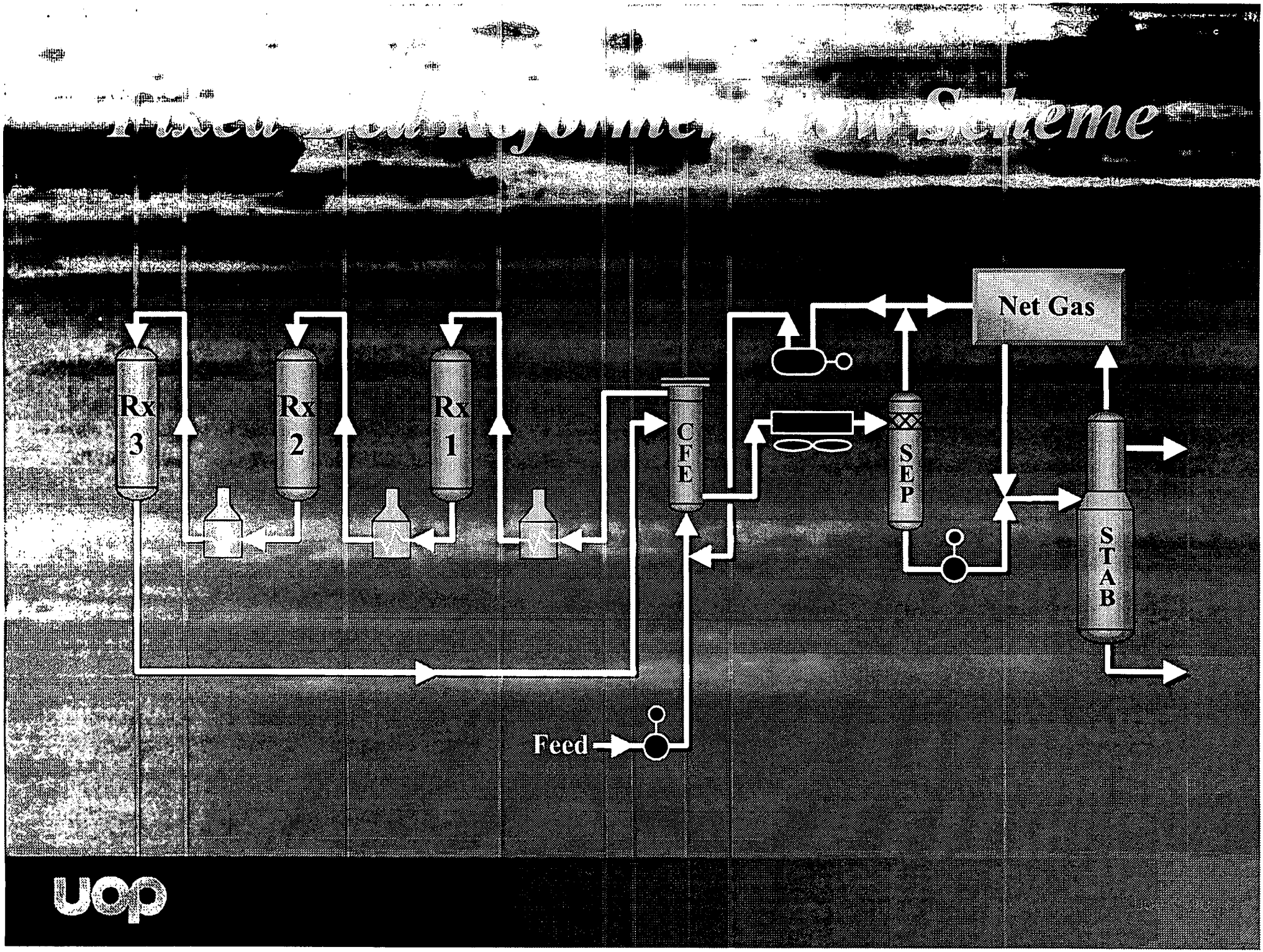
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Fixed-Bed Reformer Operation

Feed Properties	
Paraffins	61.1 lv-%
Naphthenes	26.7 lv-%
Aromatics	12.2 lv-%
D-86 Distillation	
IPB	208°F
50%	265°F
EP	376°F
API Gravity	56.9

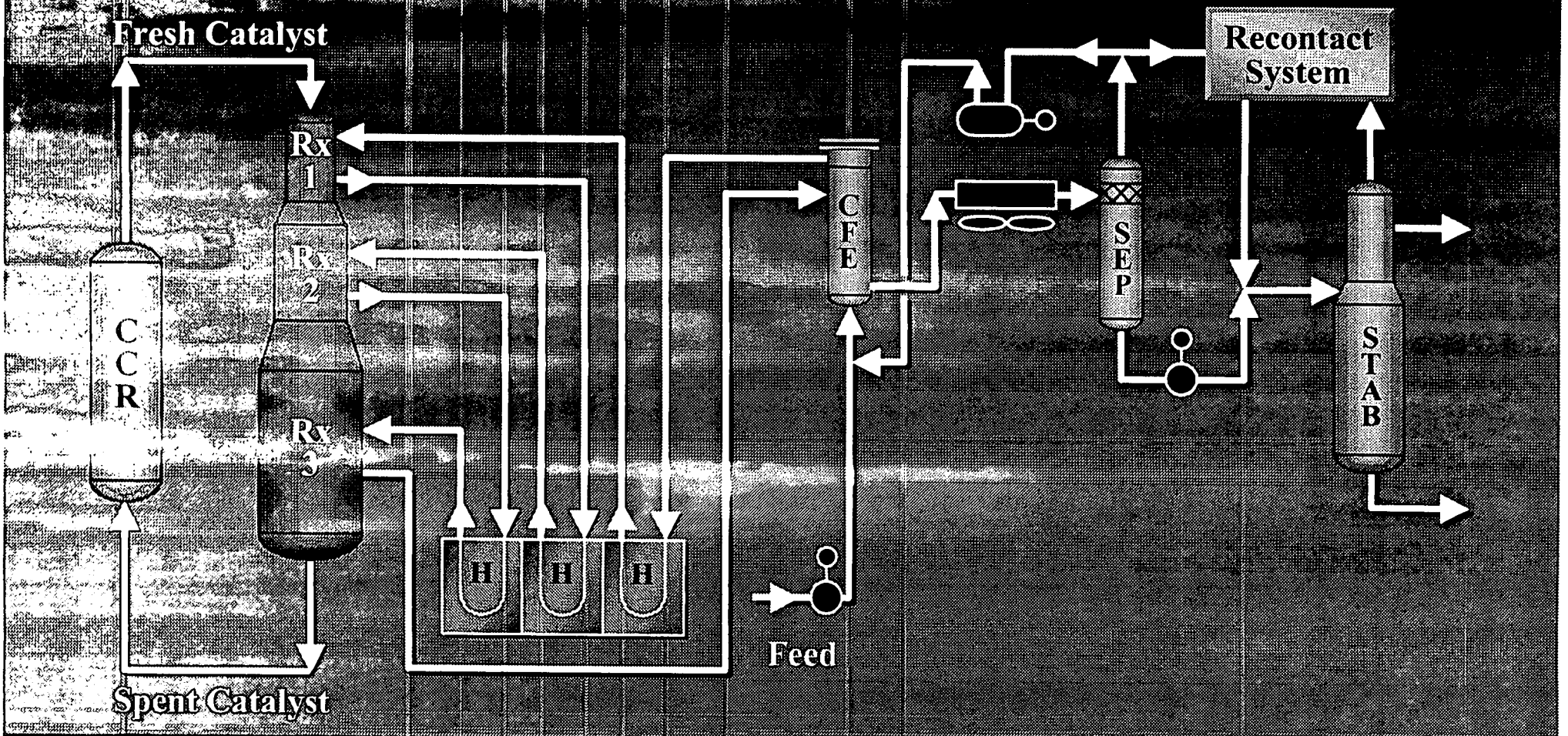
Current Operating Conditions	
Flow rate, BPSD	12,000
Overall LHSV, hr-1	1.70
H_2/HC, molar	5.0
Avg. Rx. Pressure, psig	330
C_5^+ RONC	98.0
Catalyst length, months	14.0

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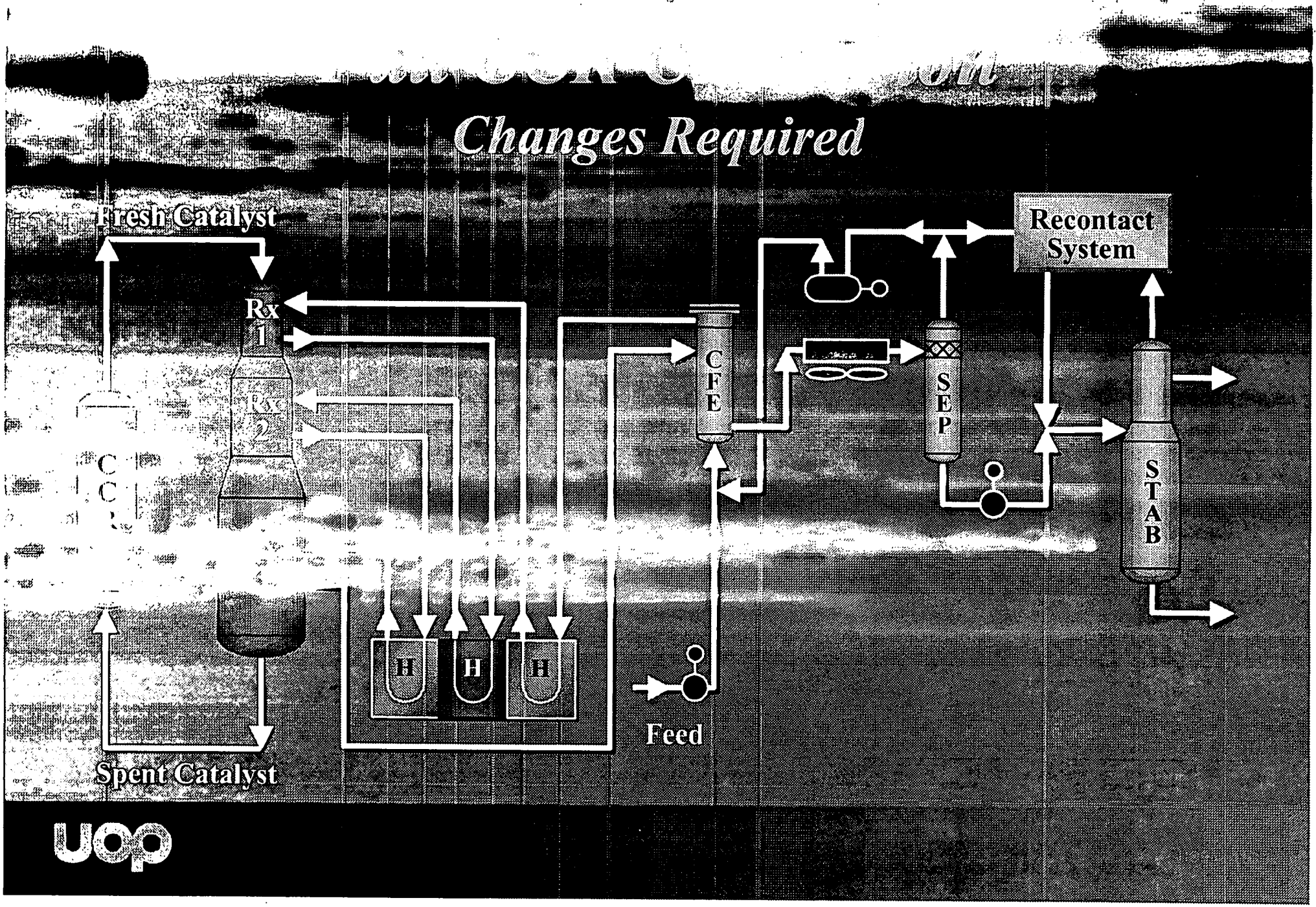

Net Gas
Rx 3
Rx 2
Rx 1
CFE
SEP
STAB
Feed
uop

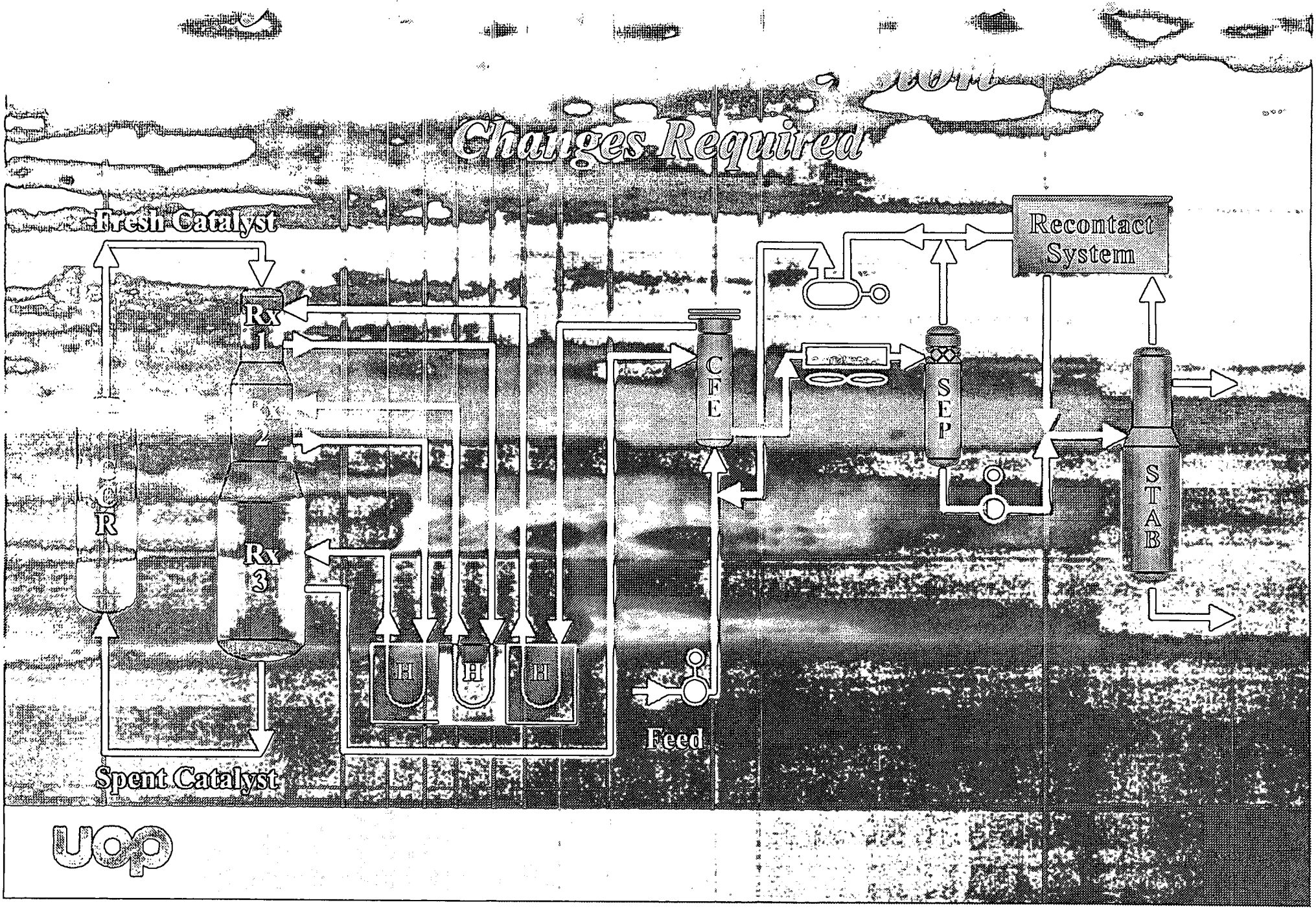
Full CCR Conversion

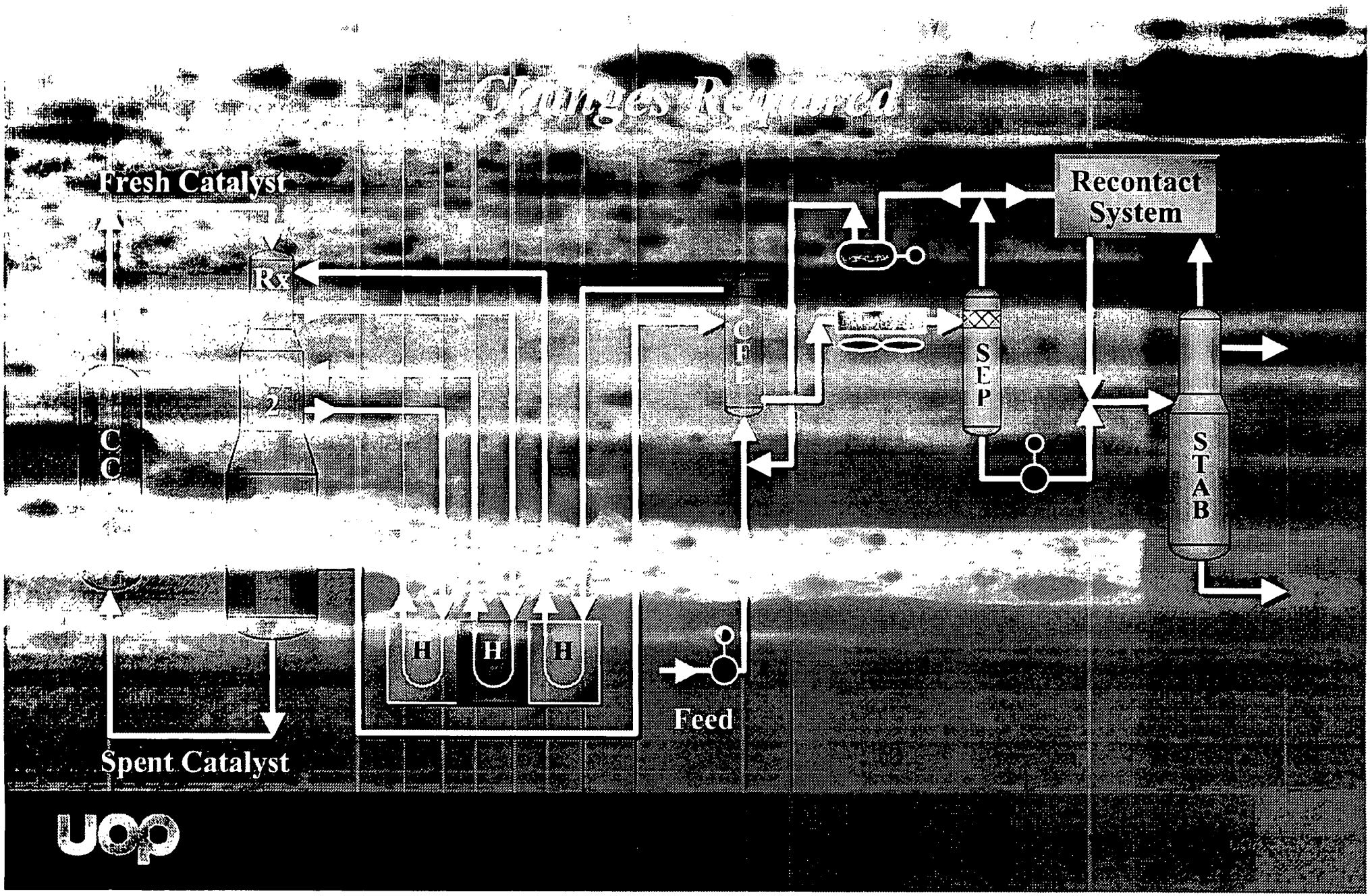
Changes Required

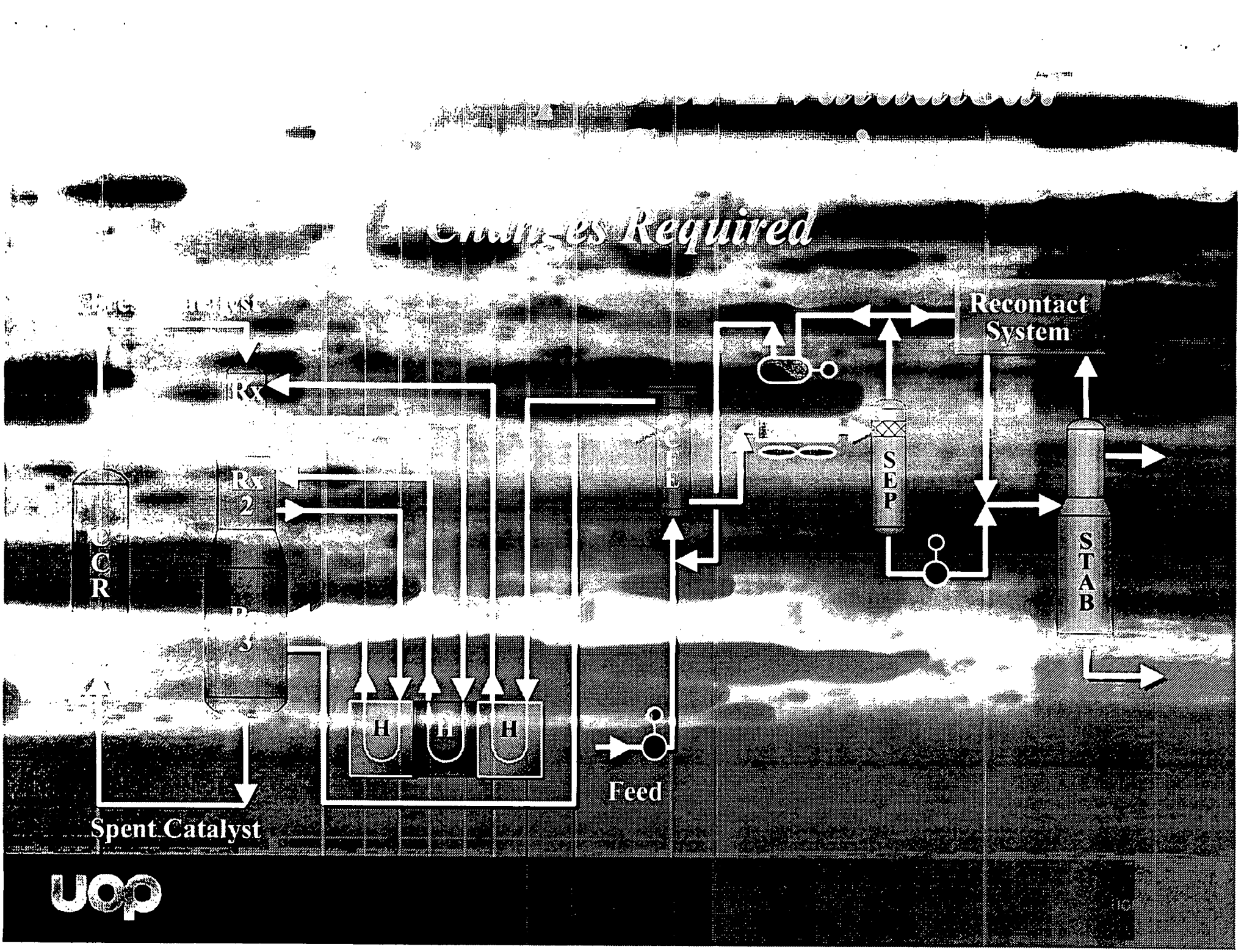


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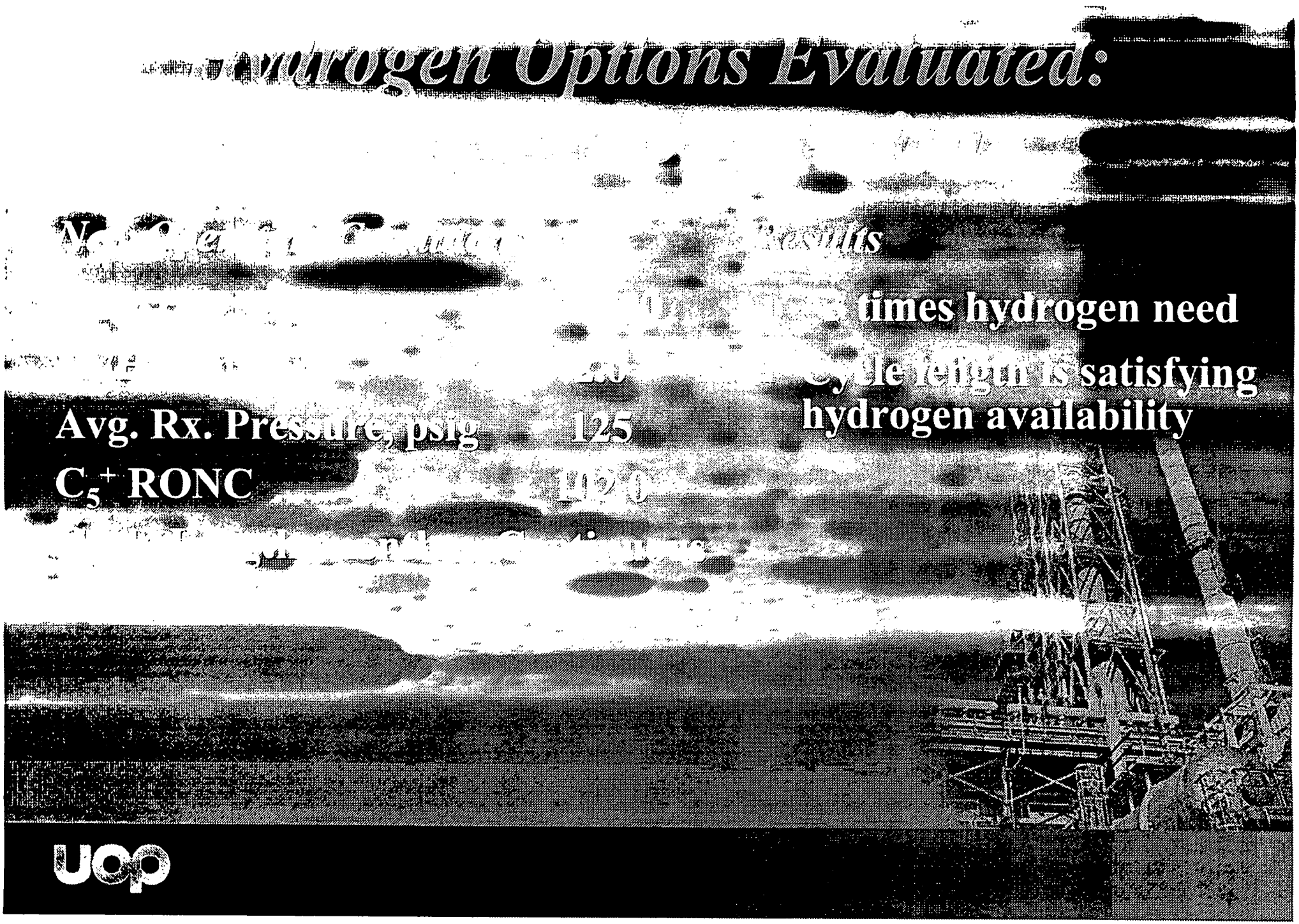

Changes Required
Fresh Catalyst
Rx 1
Rx 2
CFE
SEP
Recontact System
STAB
H
H
H
Feed
Spent Catalyst
UOP


Changes Required
Fresh Catalyst
Rx 1
Rx 2
Rx 3
CR
H
H
H
CFE
SEP
Recontact System
STAB
Feed
Spent Catalyst
UOP


Changes Required
Fresh Catalyst
Recontact System
R
C
C
SEP
STAB
H
H
H
Feed
Spent Catalyst
UOP


Recontact System
Rx
Rx 2
CCR
SEP
STAB
H
H
H
Feed
Spent Catalyst
uop

Hydrogen Options Evaluated:



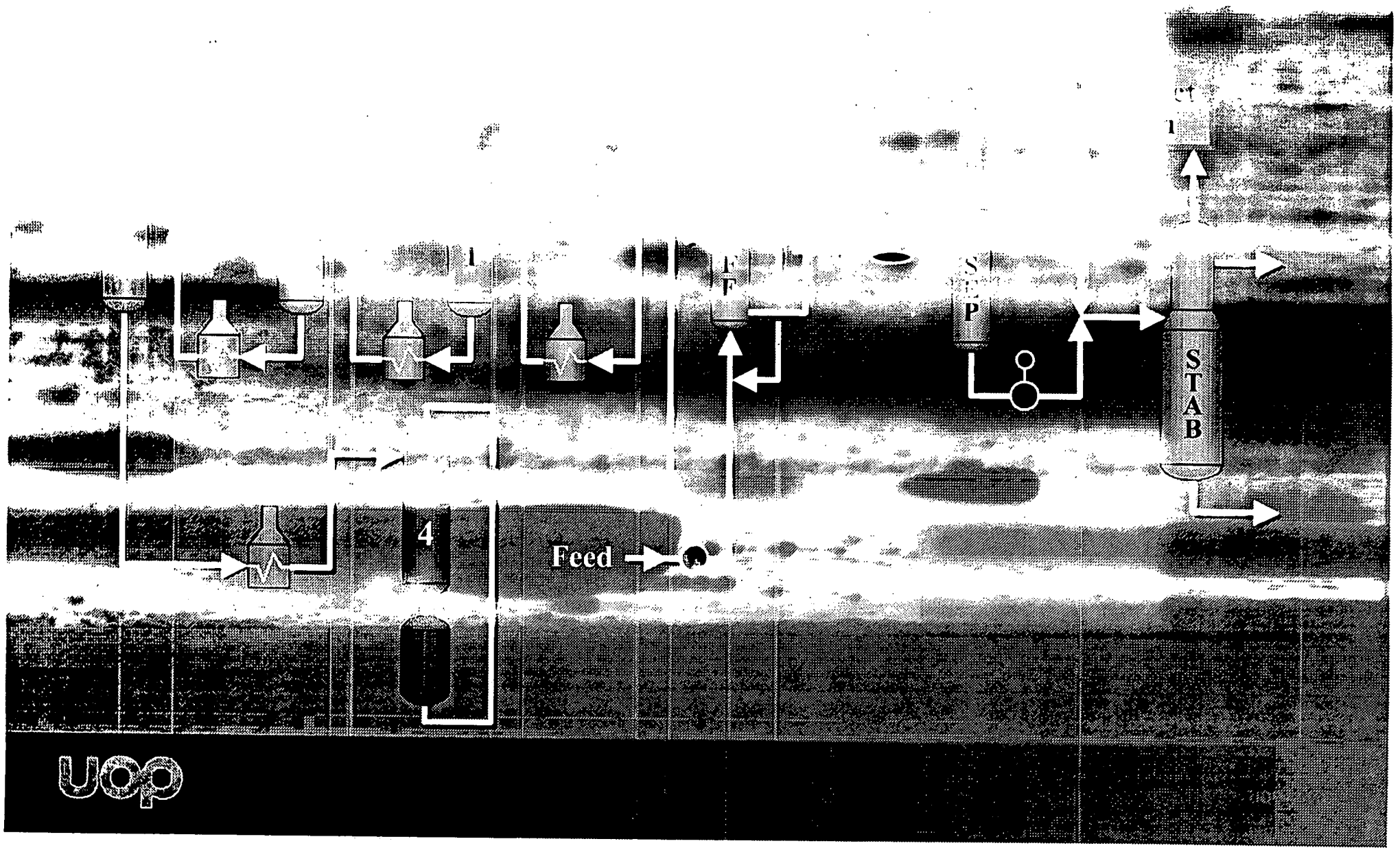
UOP

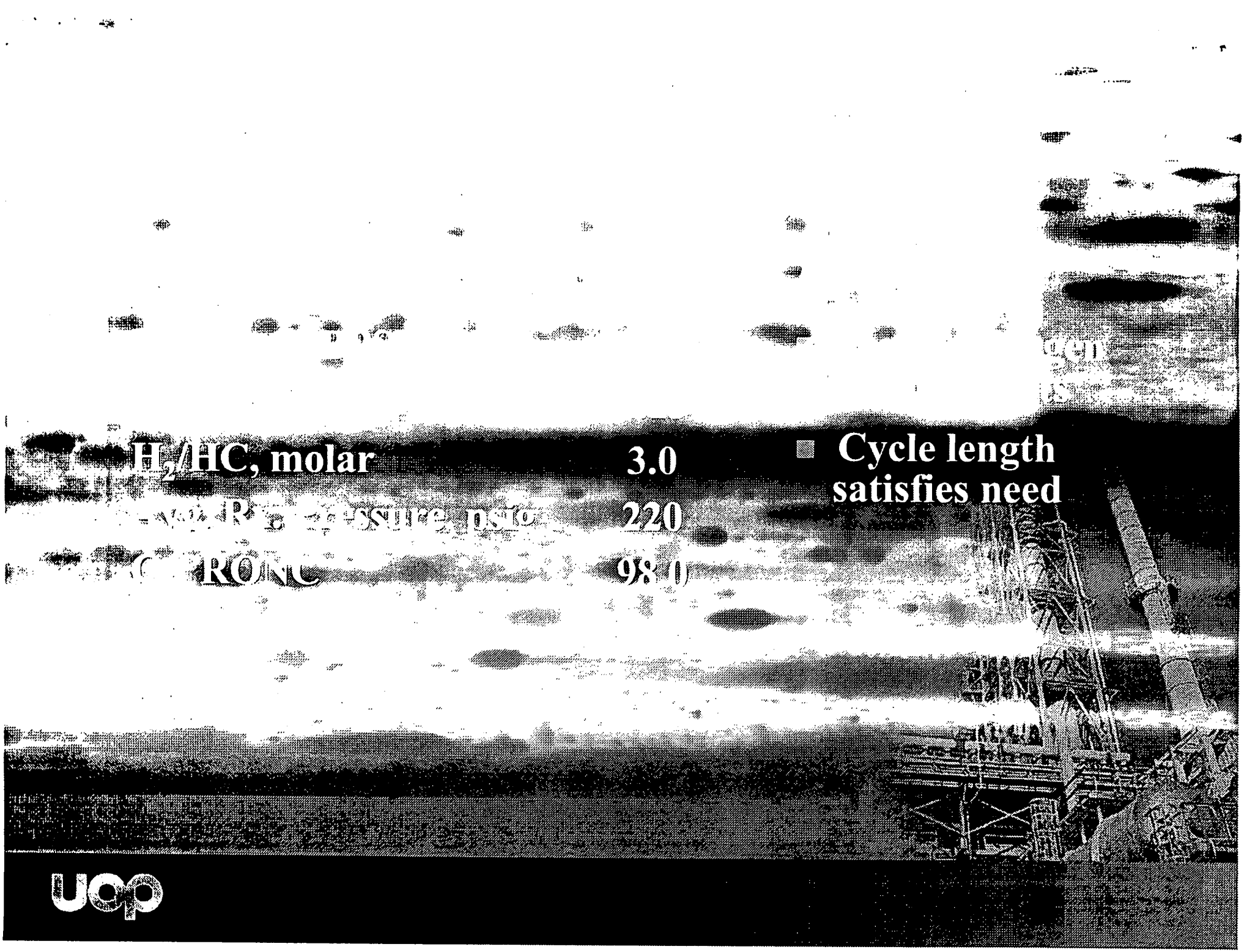
		Platforming
		0 (92.7)
-octane-barrels per year, MM	Base	24

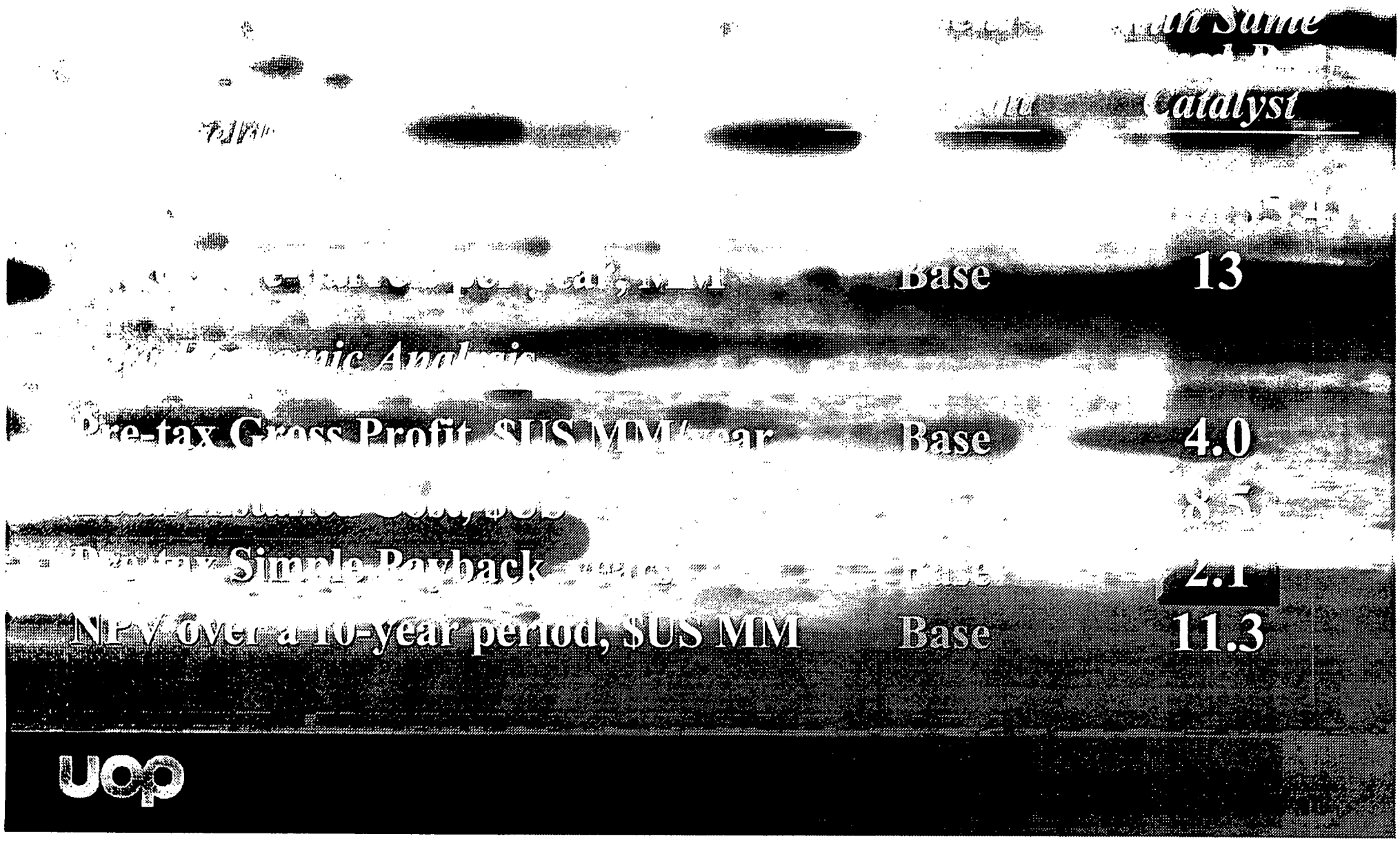
Delta Economic Analysis

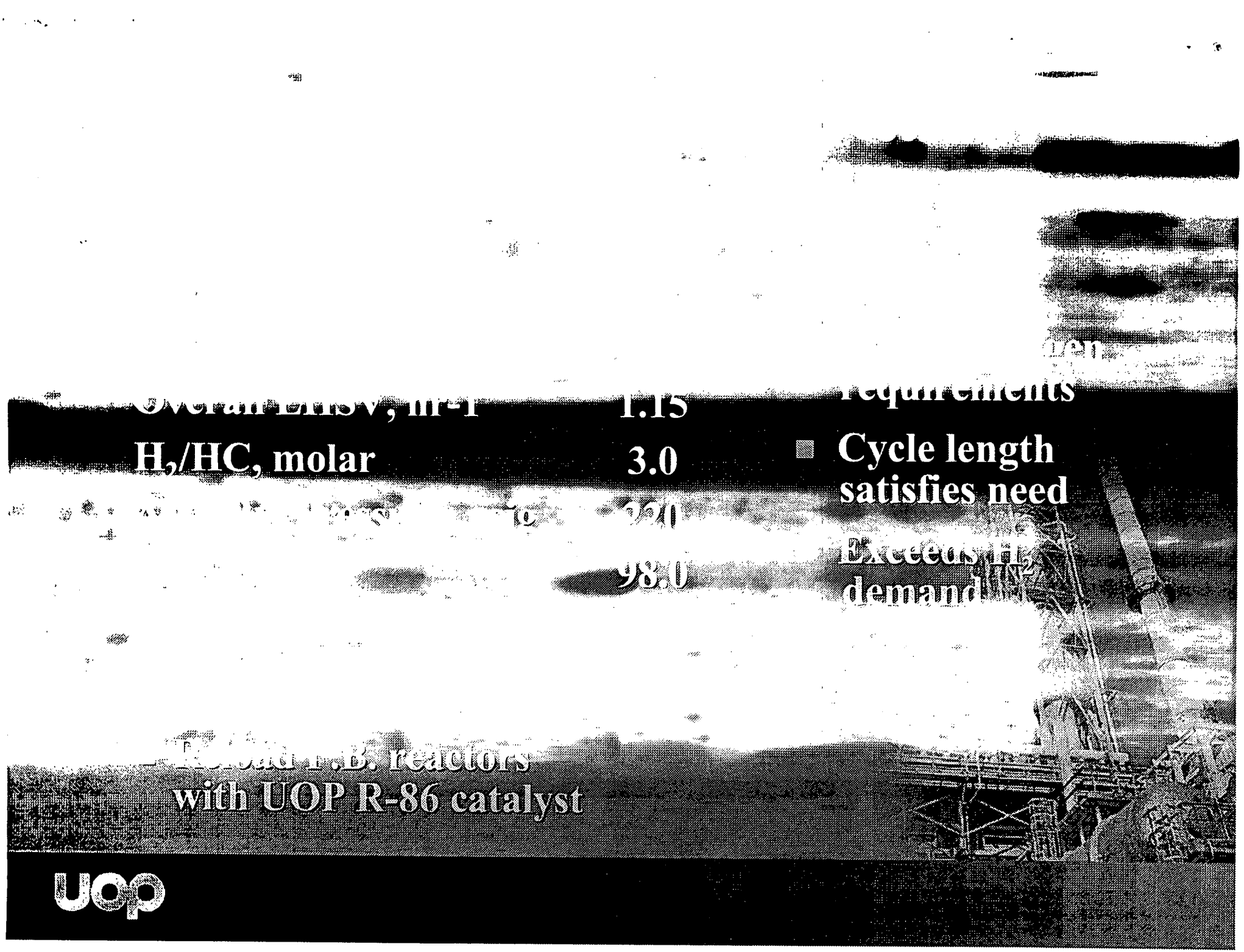
Pr... Gross Profit, $US MM/year	Base	12.9
Total Installed Cost, $		30.6
back, years	Base	2.4
NPV over a 10-year period, $US MM	Base	33.4

UOP


1
F
S
P
STAB
4
Feed
UOP

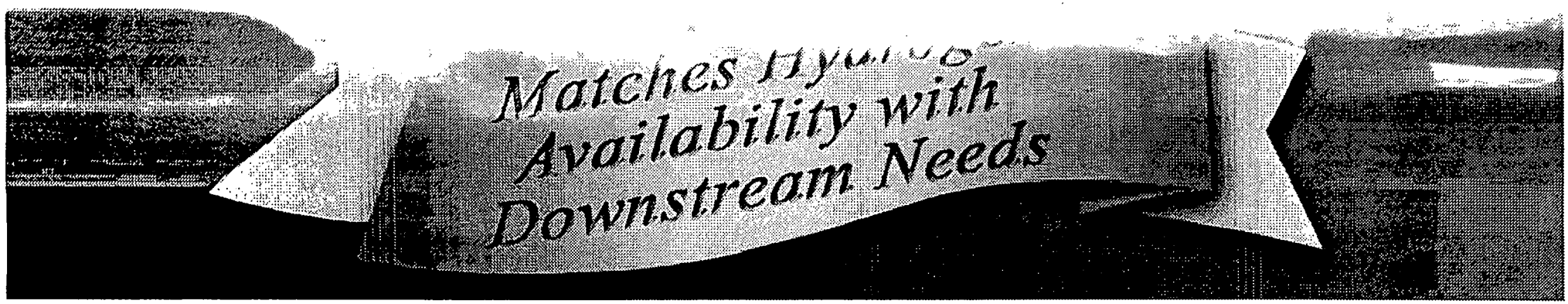

H_2/HC, molar
3.0
220
98.0
Cycle length satisfies need
UOP


Same
Catalyst
Base
13
Pre-tax Gross Profit, $US MM/year
Base
4.0
Simple Payback
2.1
NPV over a 10-year period, $US MM
Base
11.3
UOP


Overall LHSV, hr-1
1.15
H2/HC, molar
3.0
requirements
Cycle length satisfies need
Exceeds H2 demand
with UOP R-86 catalyst
UOP

C_5^+ octane-barrels per year, MM	Base	15
Gross profit, $US MM/year	Base	4.7
[illegible]	Base	14.3


+250 (42.1)
15
14.2
UOP


Matches Hydrology
Availability with
Downstream Needs